ALICE grows up

2001 - 2008

From Wonderland to Action in the Cavern

It all started in the CERN Cafeteria…

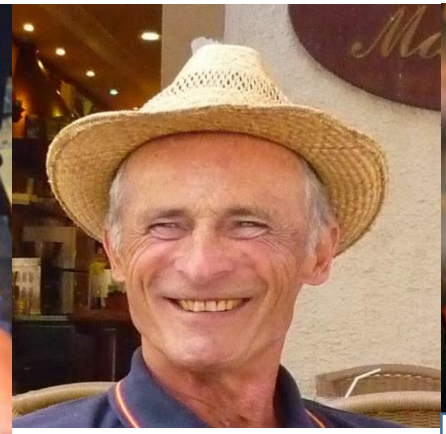
- Few days before Christmas 2000, chance encounter with Lodovico Riccati, then chairperson of the Collaboration Board
- We knew each other well from a fruitful collaboration in the SPS Heavy Ion Programme
- Lodovico: Chris, would you be interested becoming the Alice Technical Co-ordinator?
- CF: let me think about it
- Following a series of discussions (W. Klempt, L. Leistam, J. Schukraft and others)
  - Presented my views on the Technical Co-ordination to Collaboration Board on 22.2. 2001

A remarkable team came together
some of the key players

Diego Perini: project engineer

Arturo Tauro
Planning; Services

Werner Riegler
Integration; Specials

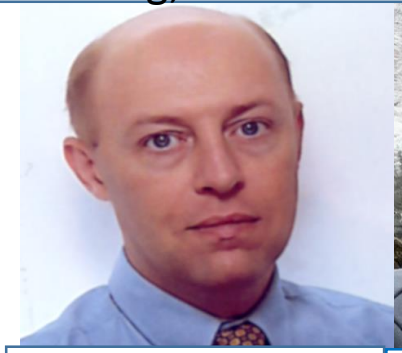


Delef Swoboda
Muon Dipole

Catherine Decosse
Budget

Hans Taureg
Reviews

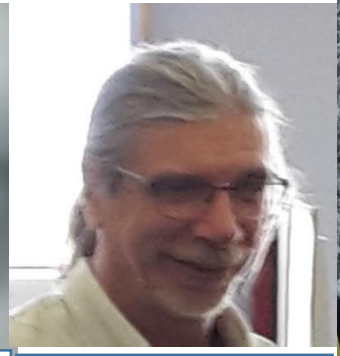
Andreas Morsch
Simulations



Fabio Formenti
Electronics

Lars Leistam
Point 2 Czar

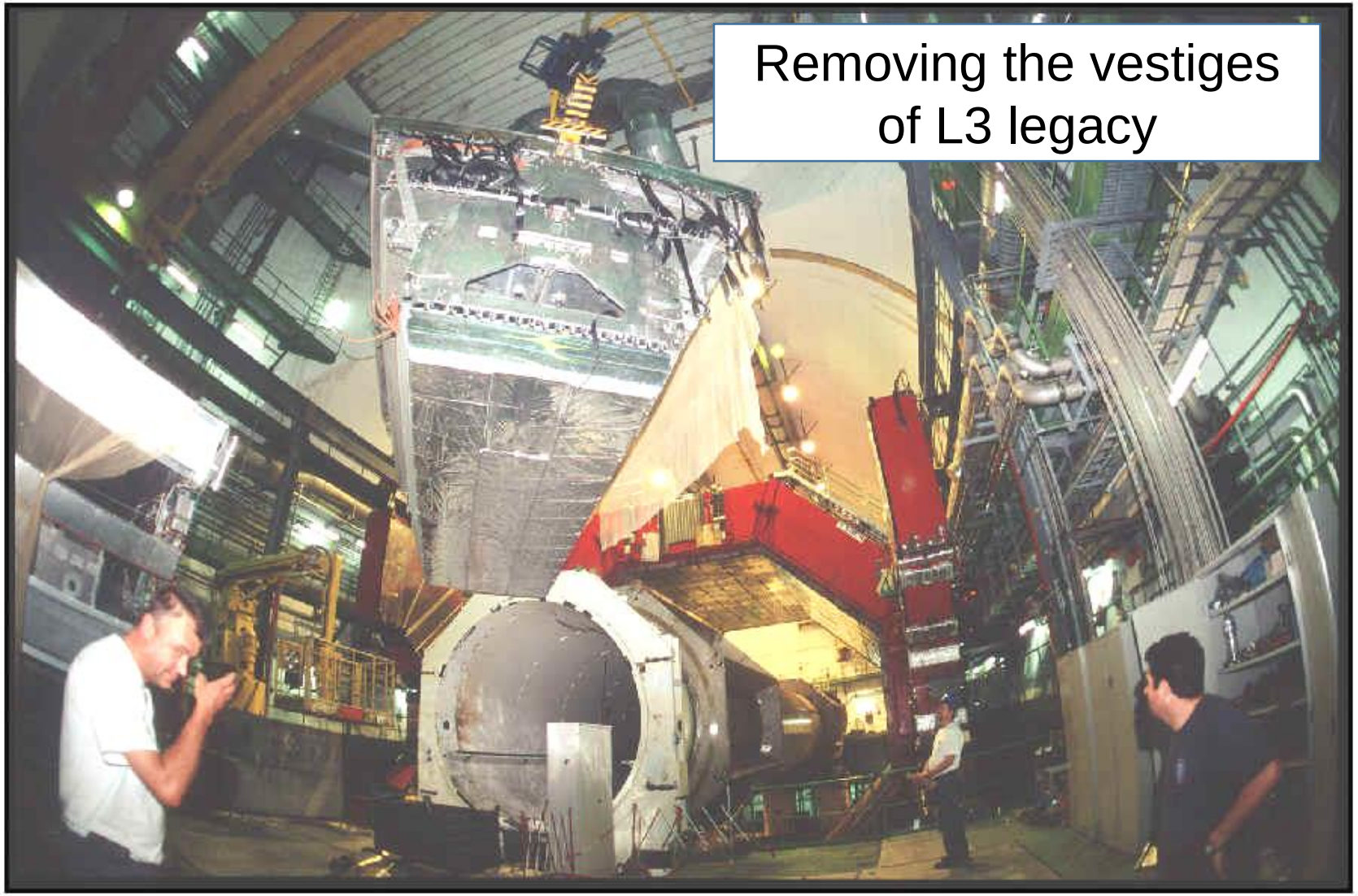
CF: enjoy working with the team



Marc Tavlet
Safety Officer

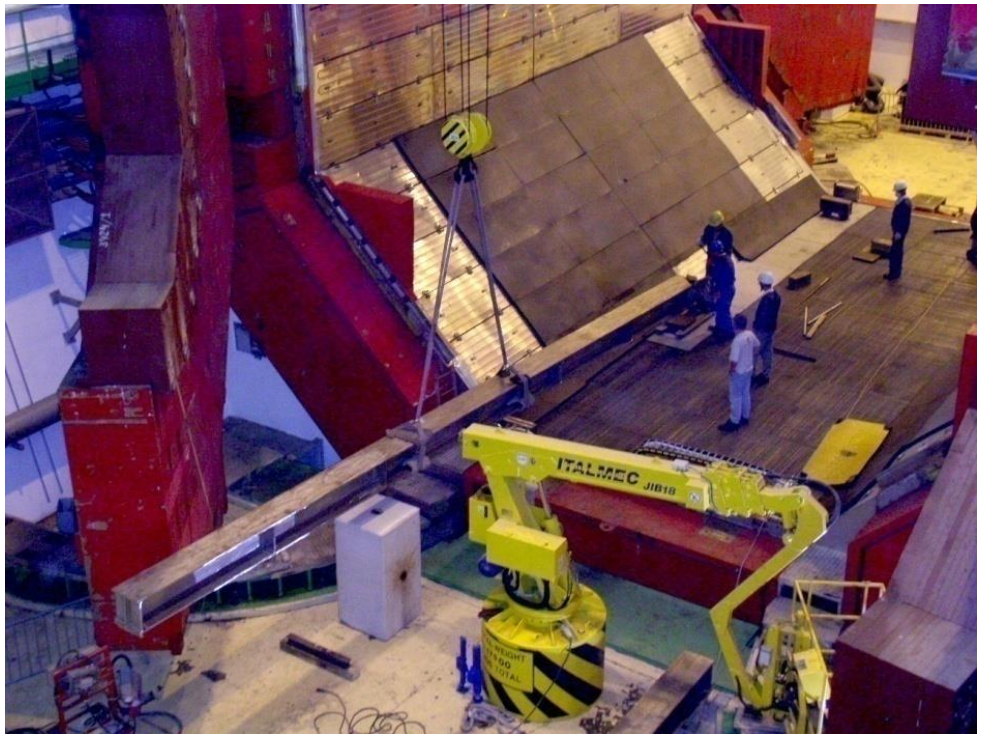
Lennart Jirden
Detector Control

First job: House Cleaning and Maintenance

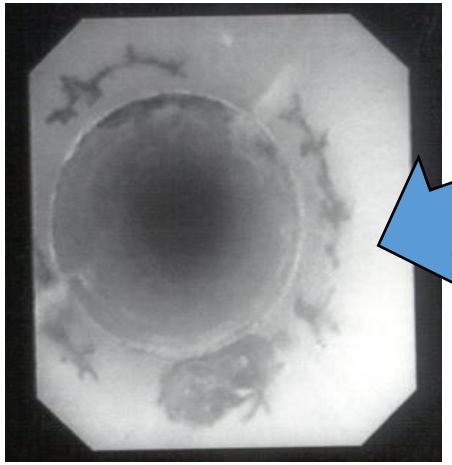


Crown Juwel L3 Magnet: world's largest resistive solenoid

Major concerns: mechanical and functional integrity, field homogeneity, temperature gradients; access to detectors, cable routing…



Alice detector must be supported on rails fixed to "Crown"



Cracks and traces of corrosion from aluminium welding of the L3 magnet cooling tubes

Extensive investigation with external experts participation.
Conclusion: better not to touch the cooling system
First powered in 1985…
still going strong after 33 years; 20 years to go…
Lars' expertise was essential

Infrastructure: Welcoming Alice

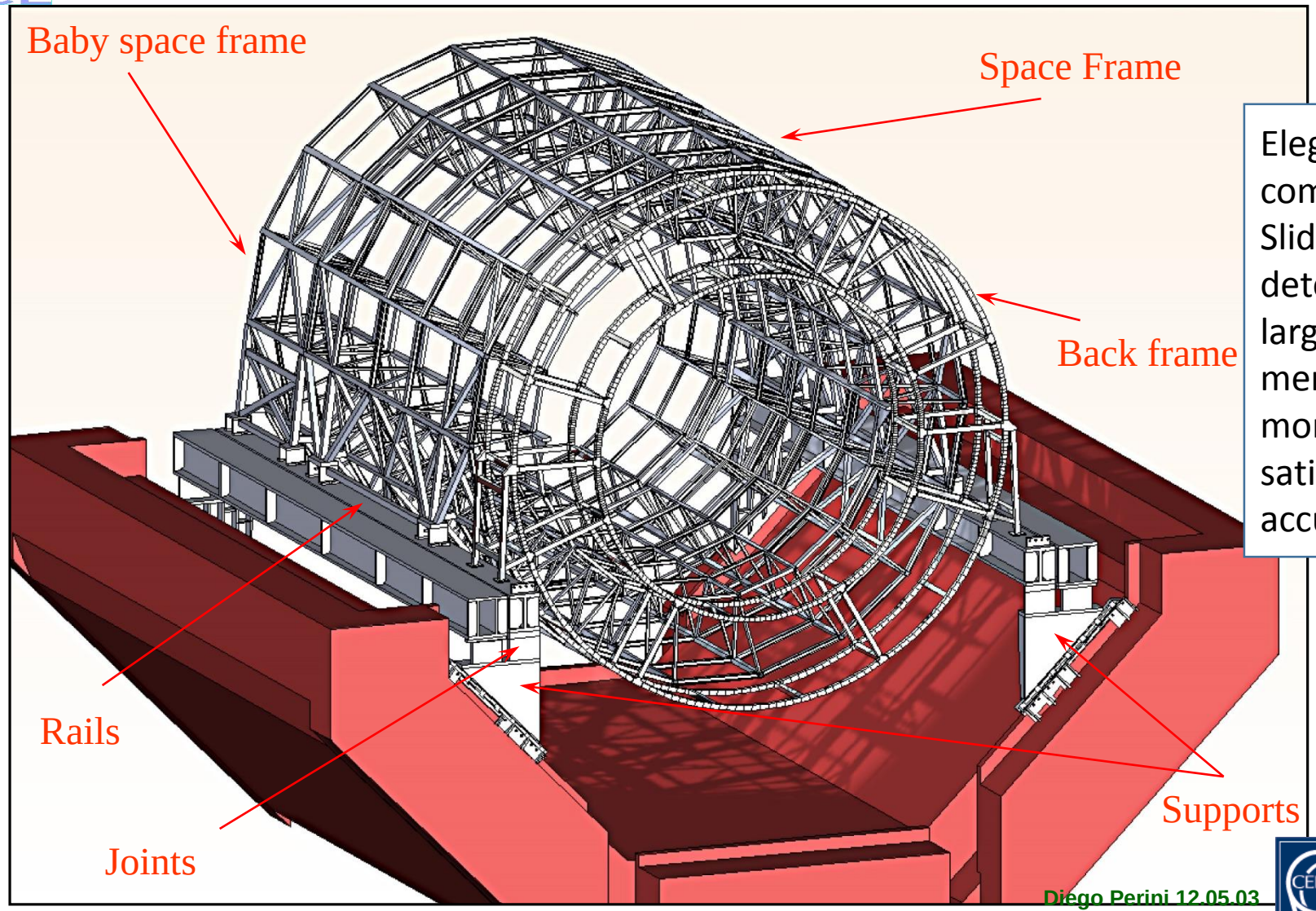
- Point 2 Mechanical Workshop
  - Culturally divers staff and the envy of the other LHC experiments (and not fully appreciated by CERN management)
- Assembly Hall:
  - Clean Room, pre-assembly, testing, pre-installation
- Space Frame
  - Stabilizing motions (and emotions)
- Muon Absorber (Ad)venture
  - Ingenuity and pragmatism saves the day
- Muon Dipole

Workshop: in many ways a boon for Alice

- Our Chinese team
- Led by lady engineer Lei Feng
- Staff from Armenia, Pakistan, Russia

Chinese New Year Lunch Break

(Infra)Structures in L3: cylindrical drawers

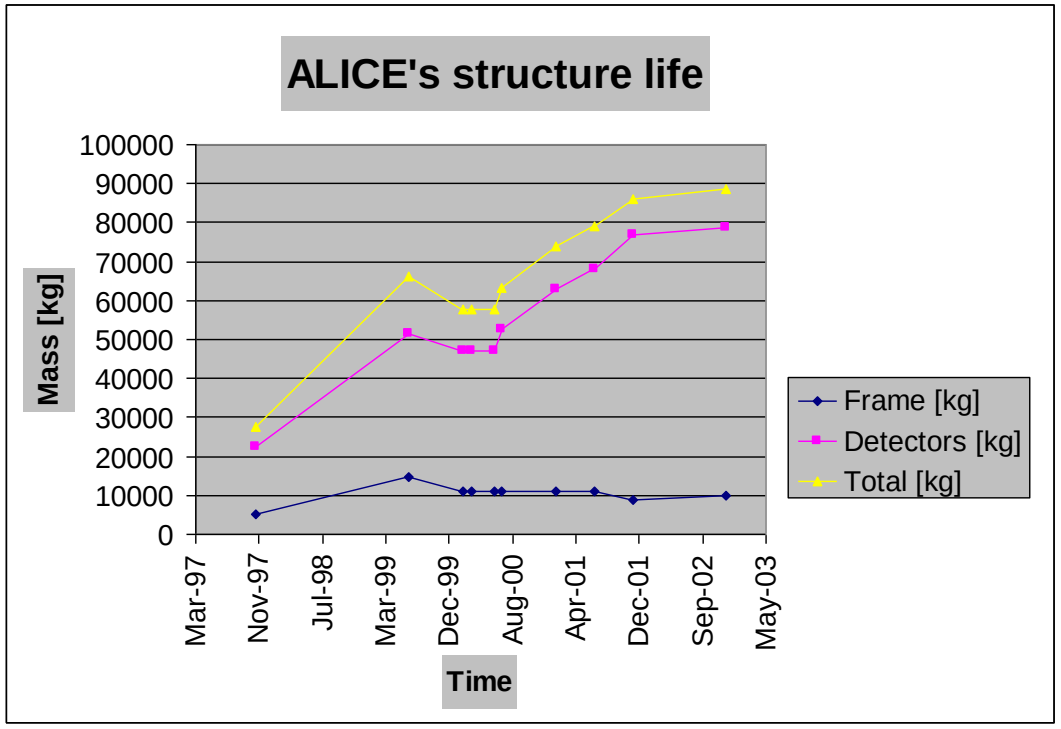


Elegant concept, complex in execution: Sliding supports and detectors into position: large (~10 mm) displace-ments. Required monitoring and compen-sation with sub-mm accuracy.

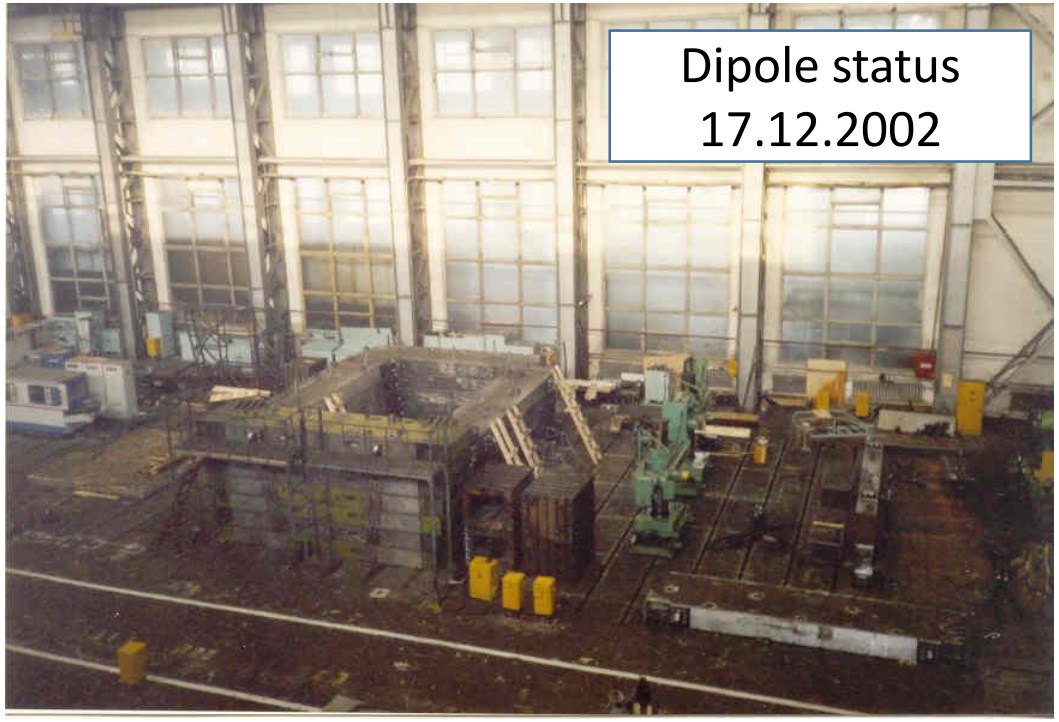
Space Frame (SF): supporting Alice' ambitions

Alice was gaining weight
Required dramatic action
SF concept: light, deformable structure
Assumes nominal shape, when fully (or symmetrically) loaded

July 2005: Load test; partial and complete loads (70 tons water) to check calculations; monitors measures space frame and rail deformation to 0.5 mm



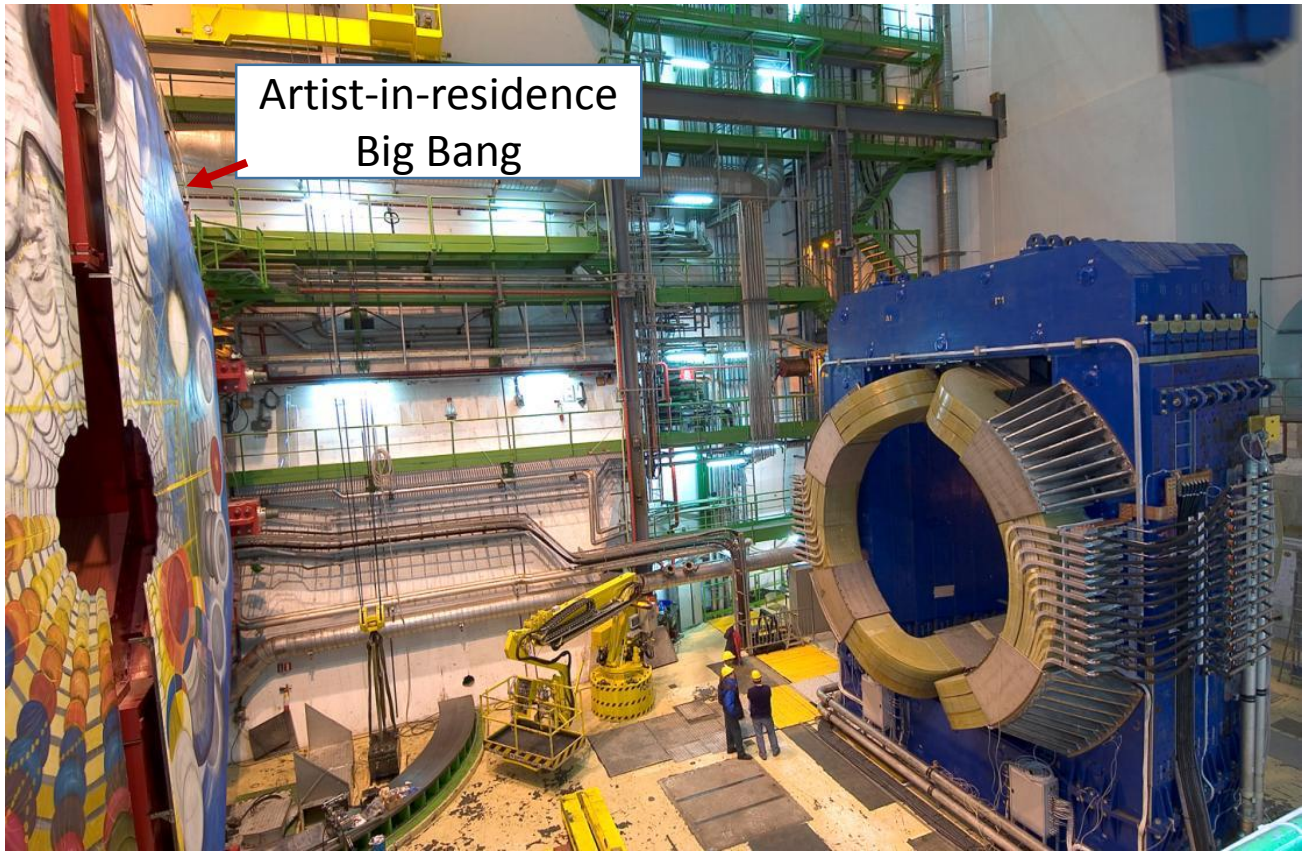
Muon magnet: From Russia (Dubna) (to CERN) with love
An (in)tense affair



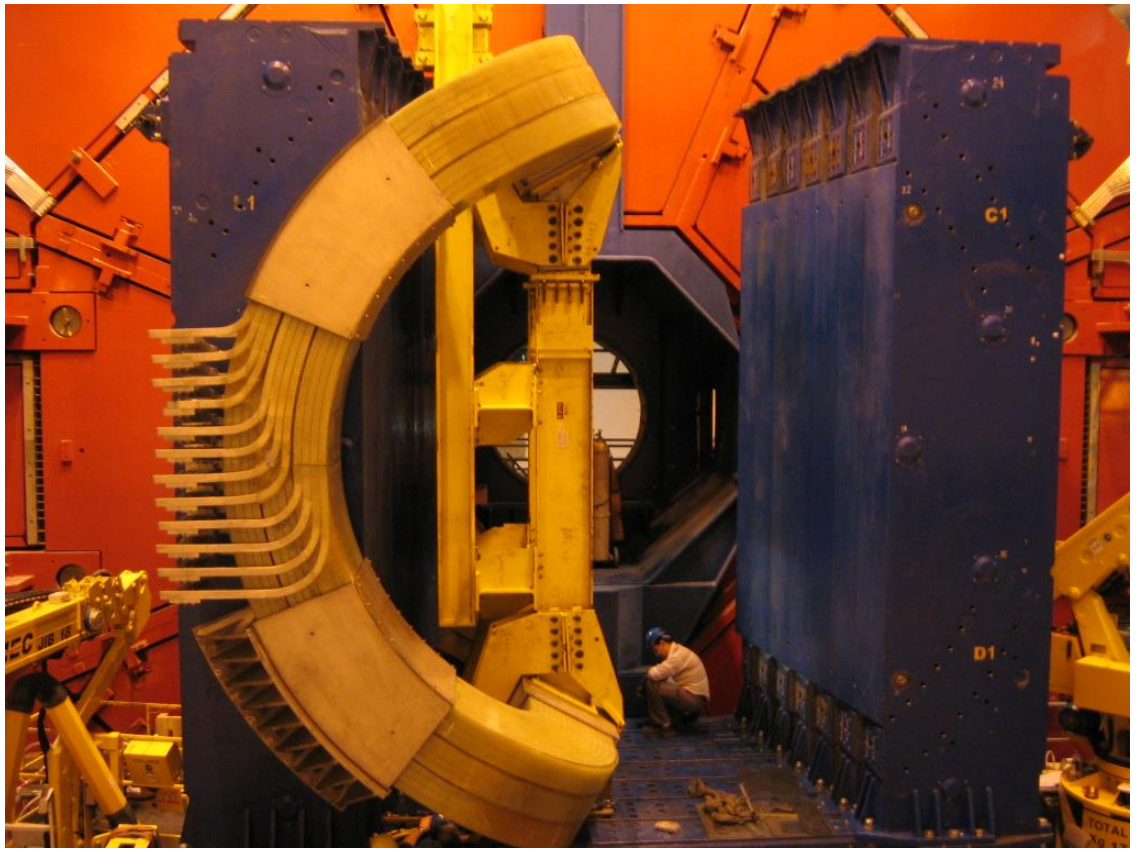
Yoke preassembled in Dubna ….horizontally
Non-optimal for verifying assembly tolerances

Transport delay: Putin had requisitioned freight wagons for a military project (???)
Stranded wagon at the Russian-Polish border

Muon Magnet: World's largest resistive dipole



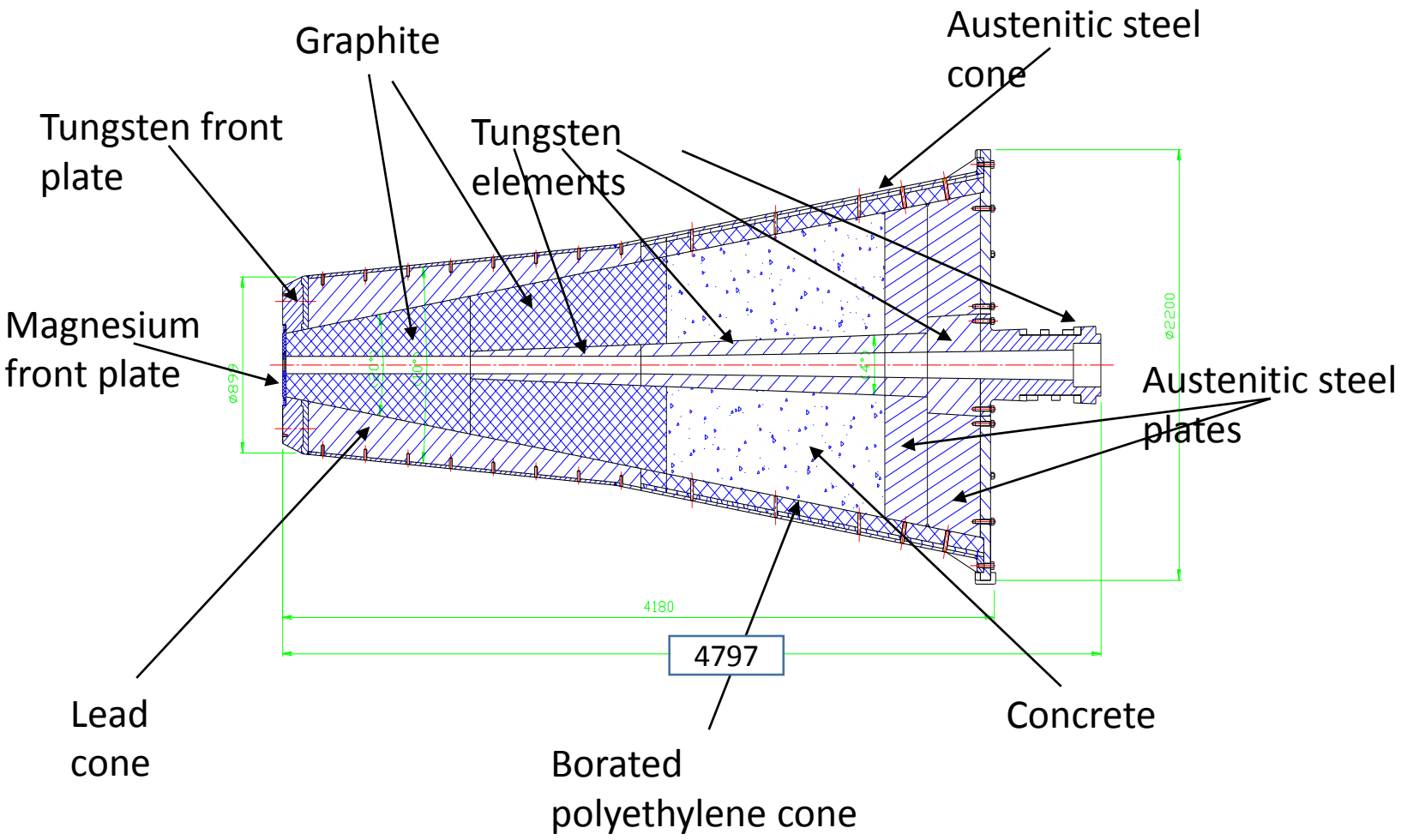
Pre-assembly finished November 2004



Tricky coil installation during final assembly
Finished April 2005

The Front Absorber (Ad)Venture: Sarov - Cern

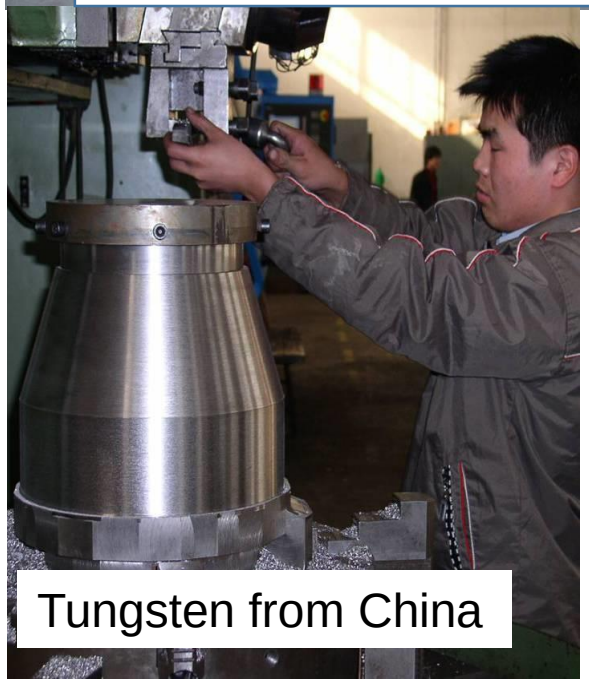
A finely tuned 40 ton instrument: gentle to muons, devastating to hadrons

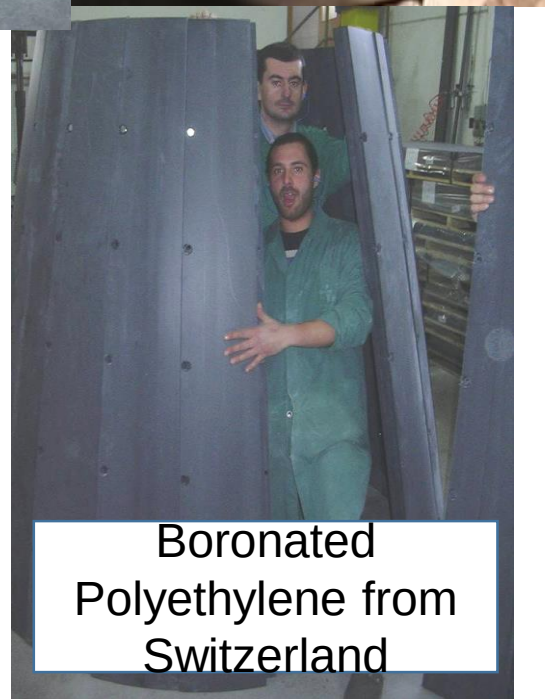


Designed in Sarov under ISTC contract

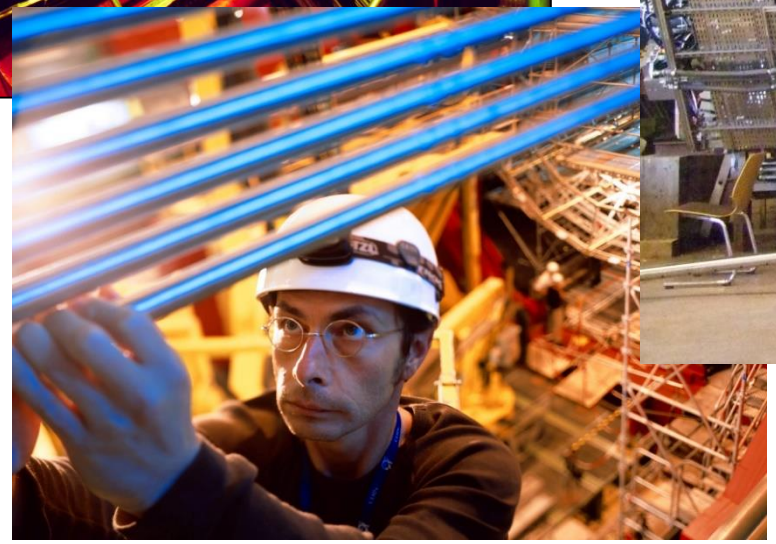
Engineering, construction, supervision at CERN to save 2 M €
Strategy: Selecting material and part manufacture from industry, world-wide and build at home

The Front Absorber: a global enterprise, IKEA Style

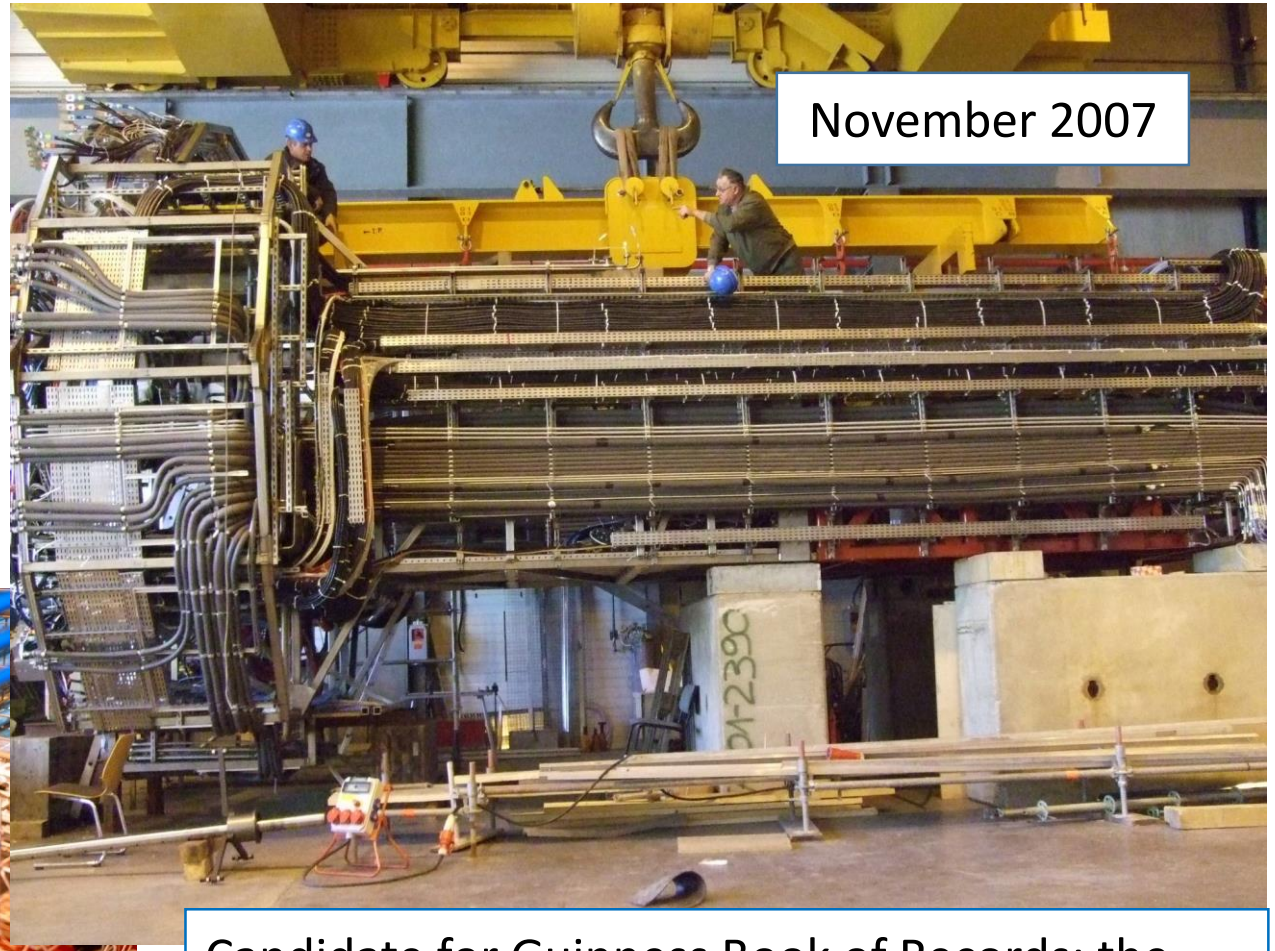




Alice' umbilical links: treated with tender care

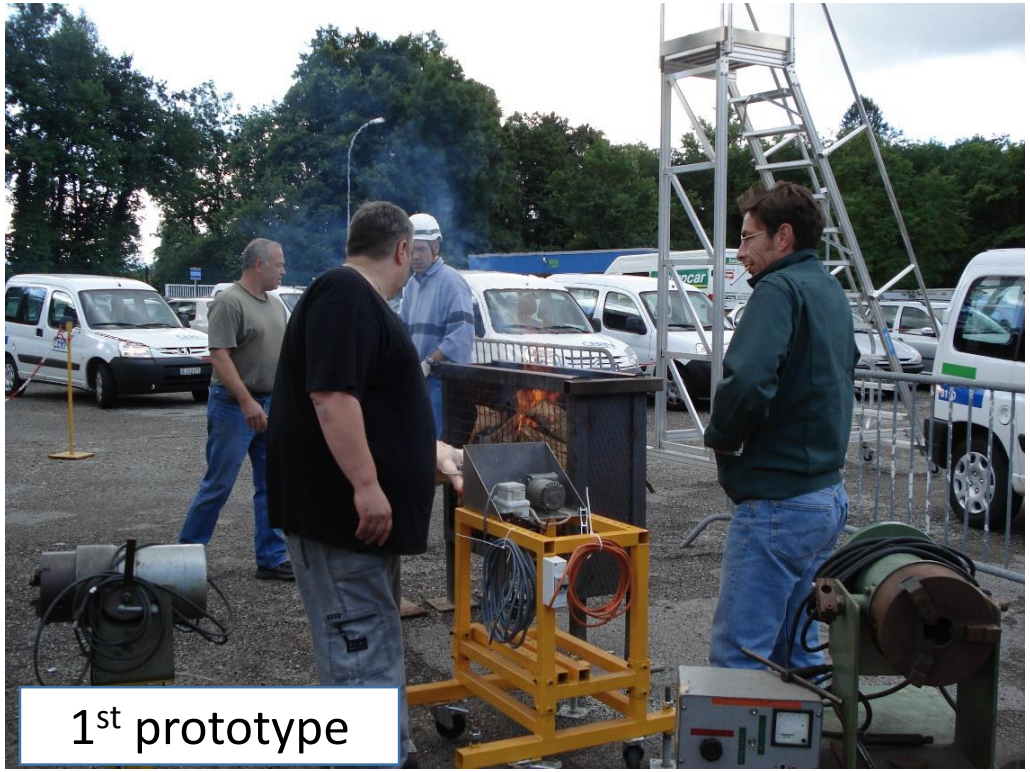


500 km cables;
30 km gas pipes
15 km cooling pipes



Candidate for Guinness Book of Records: the world's largest connector for TPC and ITS services connecting wall outlets to detectors

Proud achievement: developing the finest DCS interfaced BBQ infrastructure



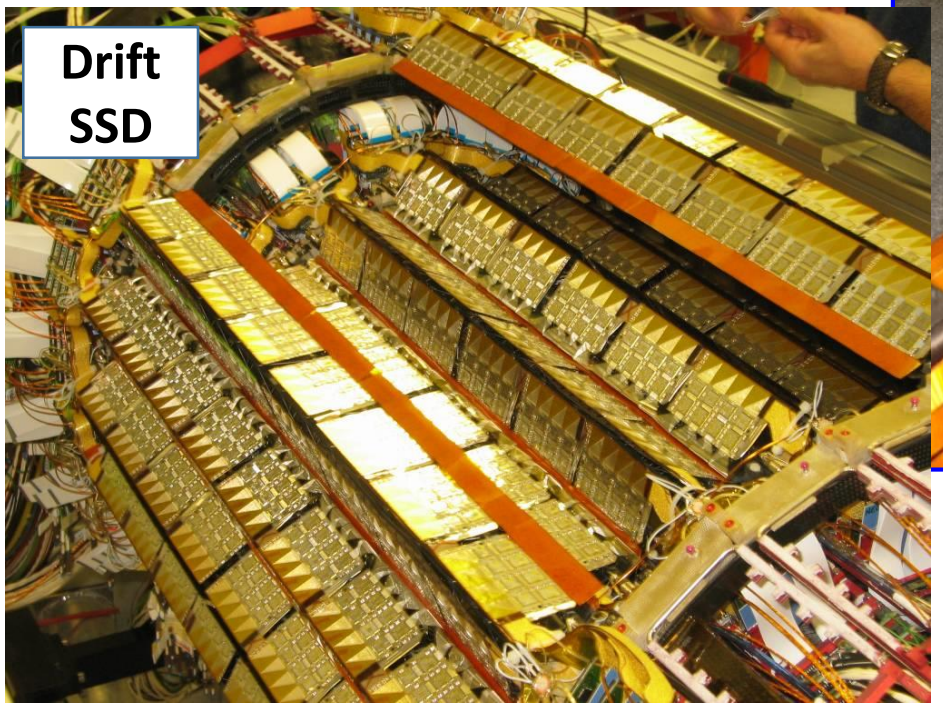
1st prototype

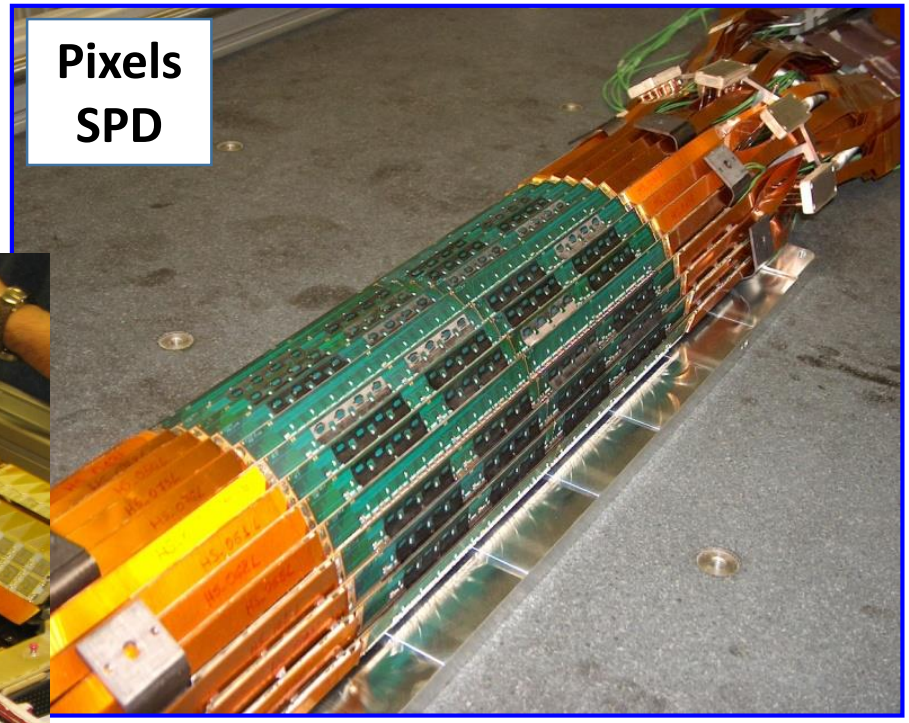
2nd generation; ongoing project

The Alice riches of detectors: selected flashbacks

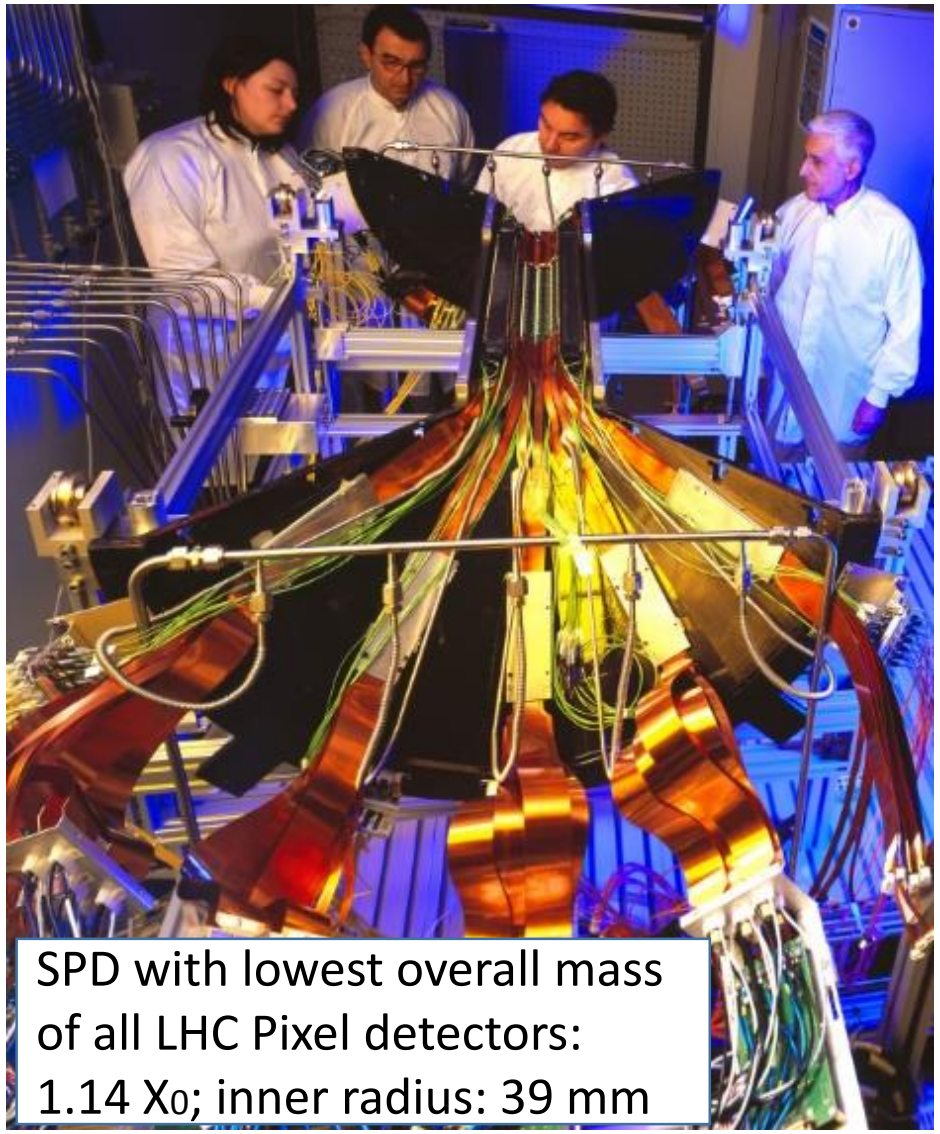
- Very large variety of detection techniques
- Performance required at the front of detector physics and technology
  - true also for all the other LHC detectors
- Several unique techniques employed
- Each detector system required international collaboration
- “Technology transfer” to laboratories new to the field
- Role of Technical Co-ordination
  - Be supportive through site visits, reviews, documentation, extensive work on integration and installation
- Apologies for not addressing major systems: DCS, DAQ, HTL …

Inner Tracking System, ITS: silicon in many incarnations
Pixels, Drift and Strips





SPD: Preassembly

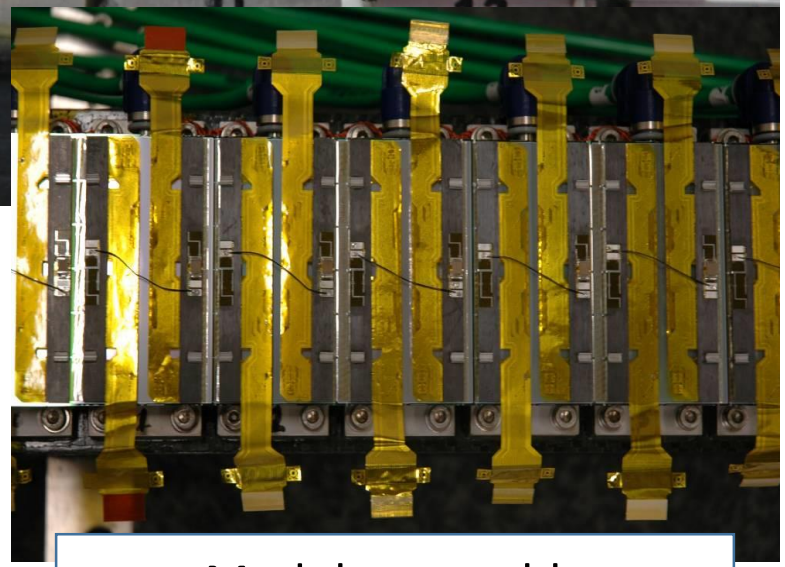


SPD with lowest overall mass of all LHC Pixel detectors: 1.14 X_0; inner radius: 39 mm

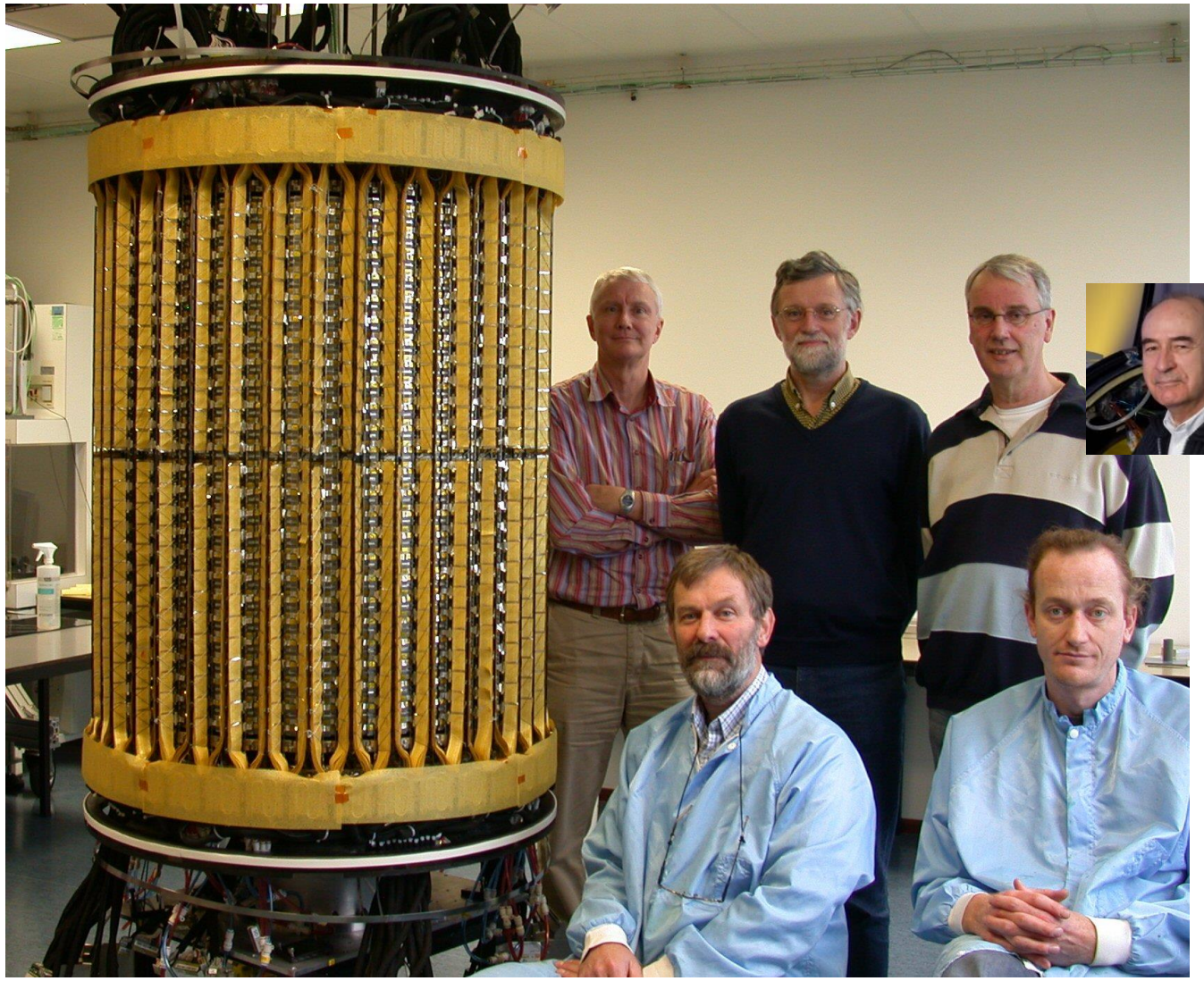
SDD: largest employment of a challenging technology

SSD: Dutch – French alliance with Russian Support(s)

Carbon fibre ladder construction at St. Petersburg

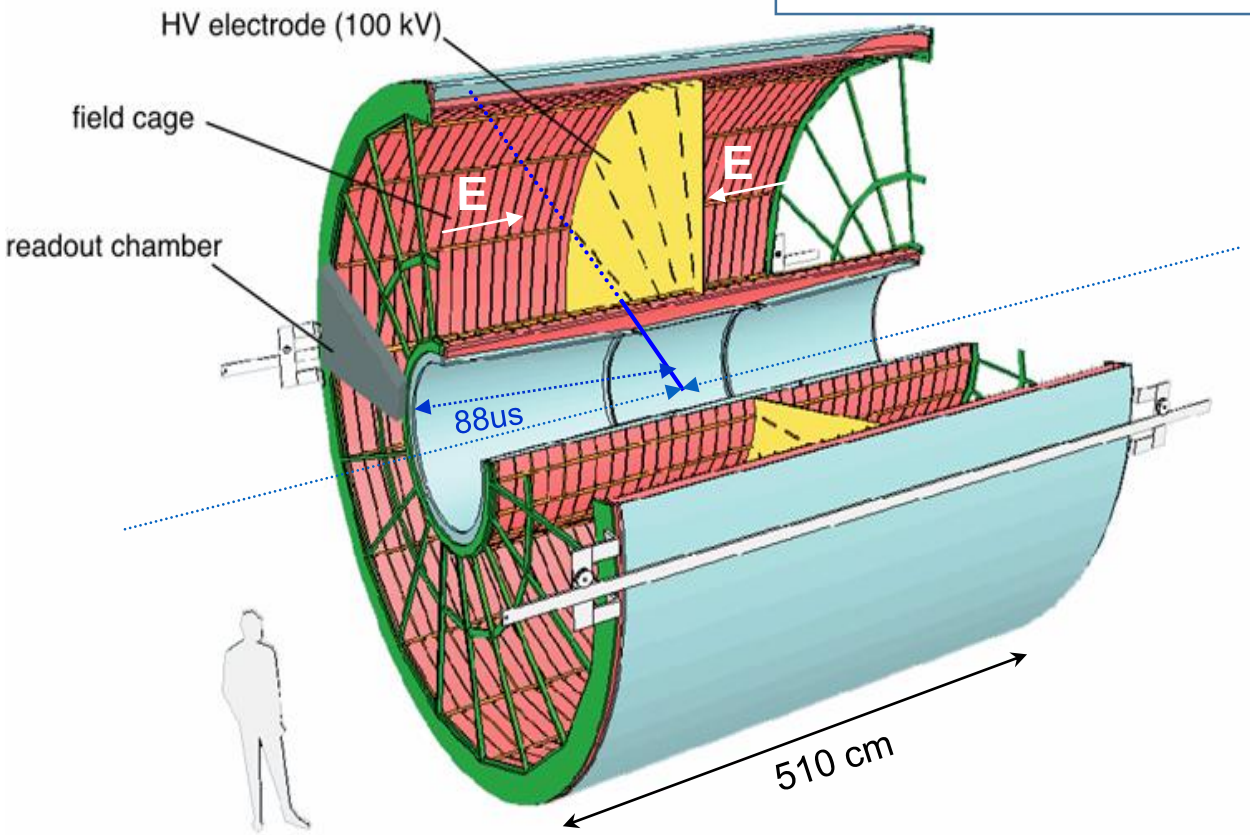


Module assembly



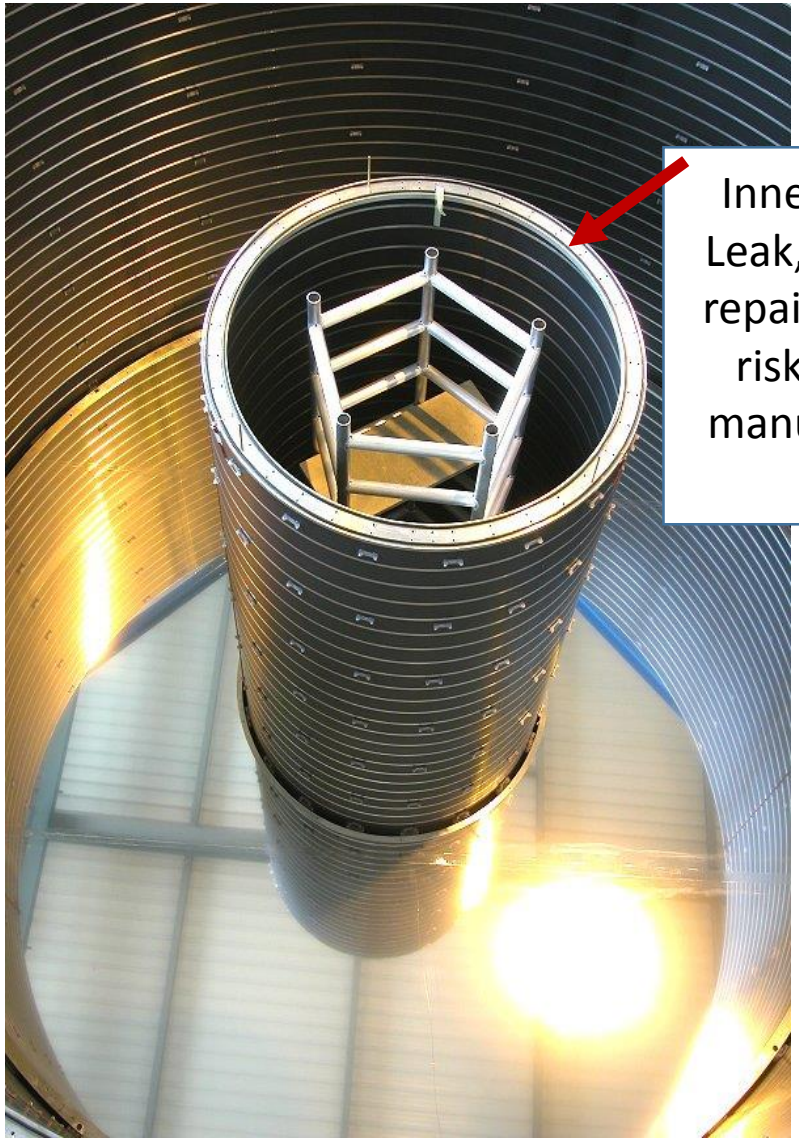
TPC: the world's largest and a marvel of mechanical and electrical precision ….at the level of 10^{-4}

From drawing to reality

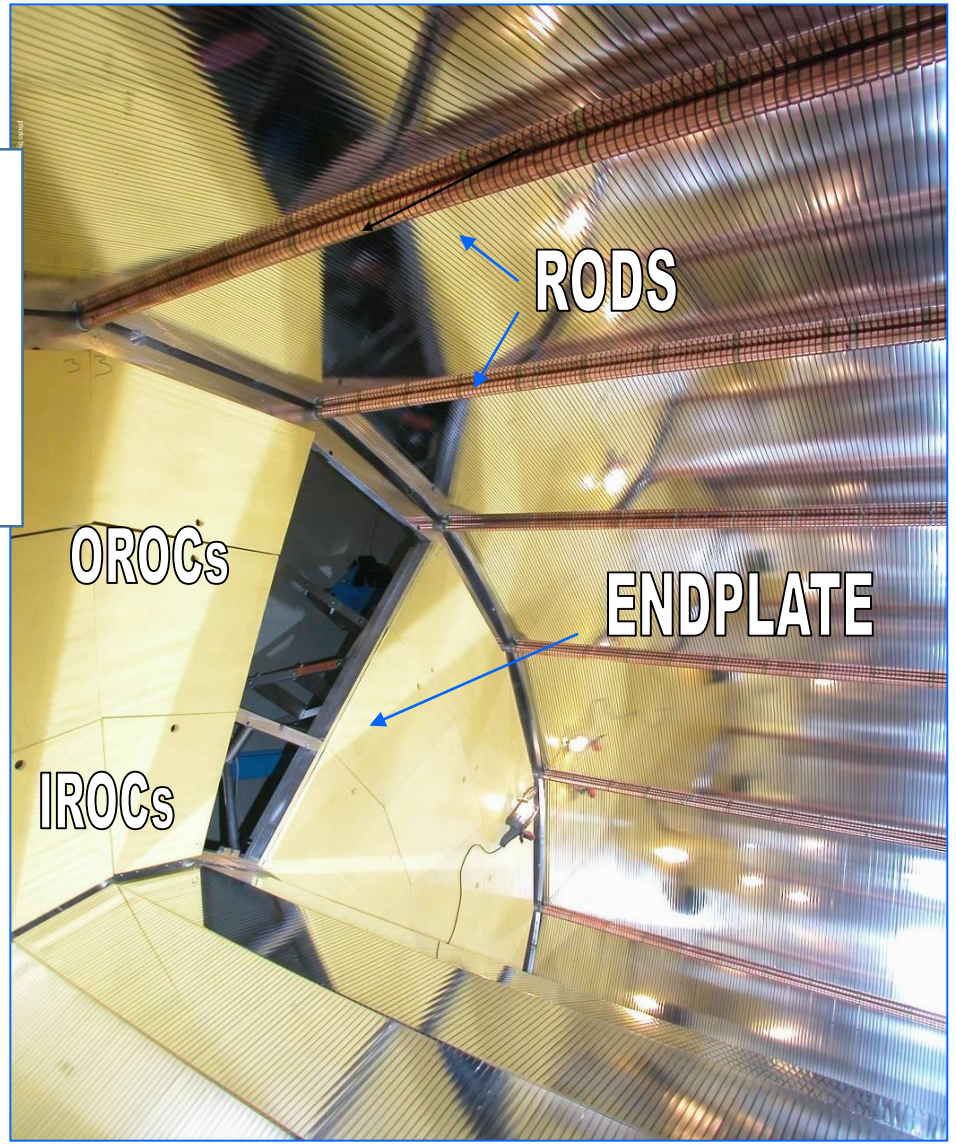


Outer cylinder: longitudinal precision: 250 µm

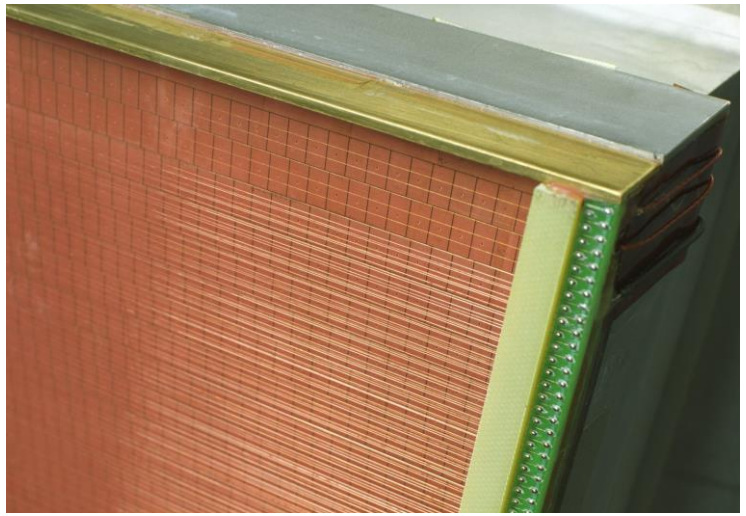
TPC: endplates with 250 µm precision
Central electrode with 10^{-4} parallelism



Inner Cylinder crisis: Leak, faulty glue joint, repair. Considered too risky; decided with manufacturer on new fabrication

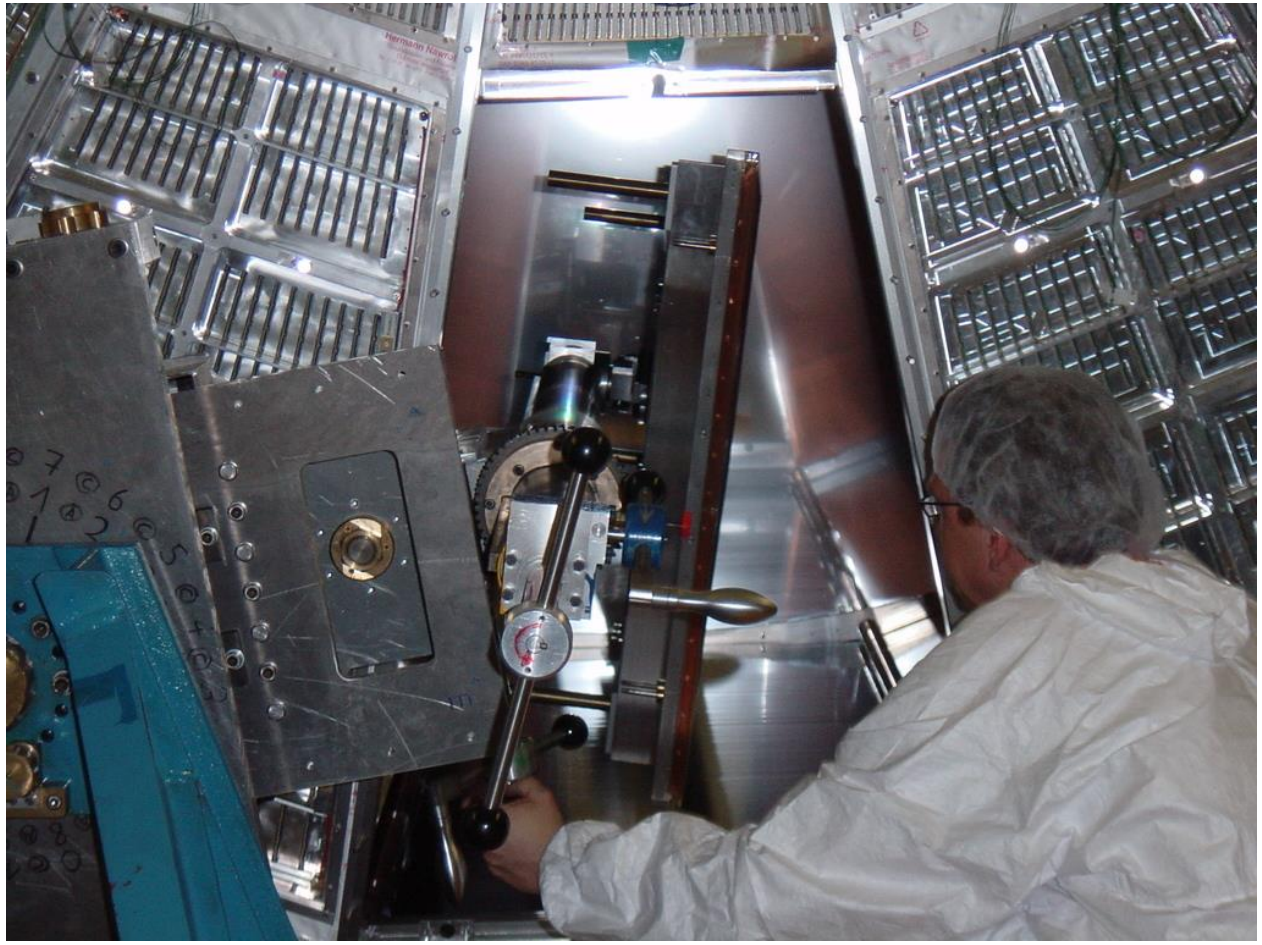


Readout chamber insertion: A nerve-wracking endeavor
Zero tolerance for failure



Close-up of the cathode pad plane

72 (+ spares) readout chambers constructed in Bratislava, GSI and Heidelberg



Chamber insertion with specially designed Insertion tool

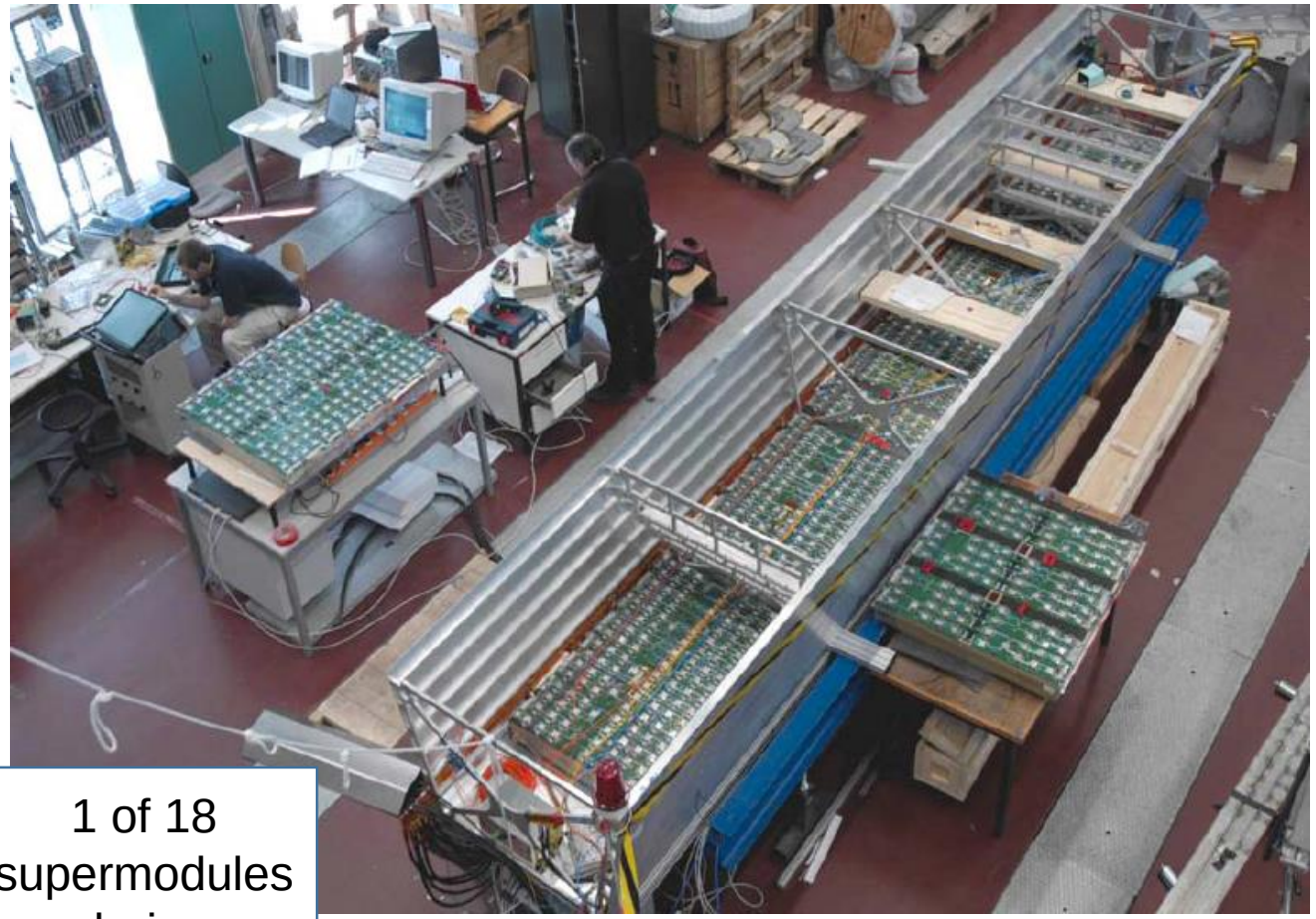
TPC Signal Processing: A World Premiere

TRD: apogee of 30 years development

1.2 * 10^6 channels; waveform analysis; e-trigger within 5 µsec

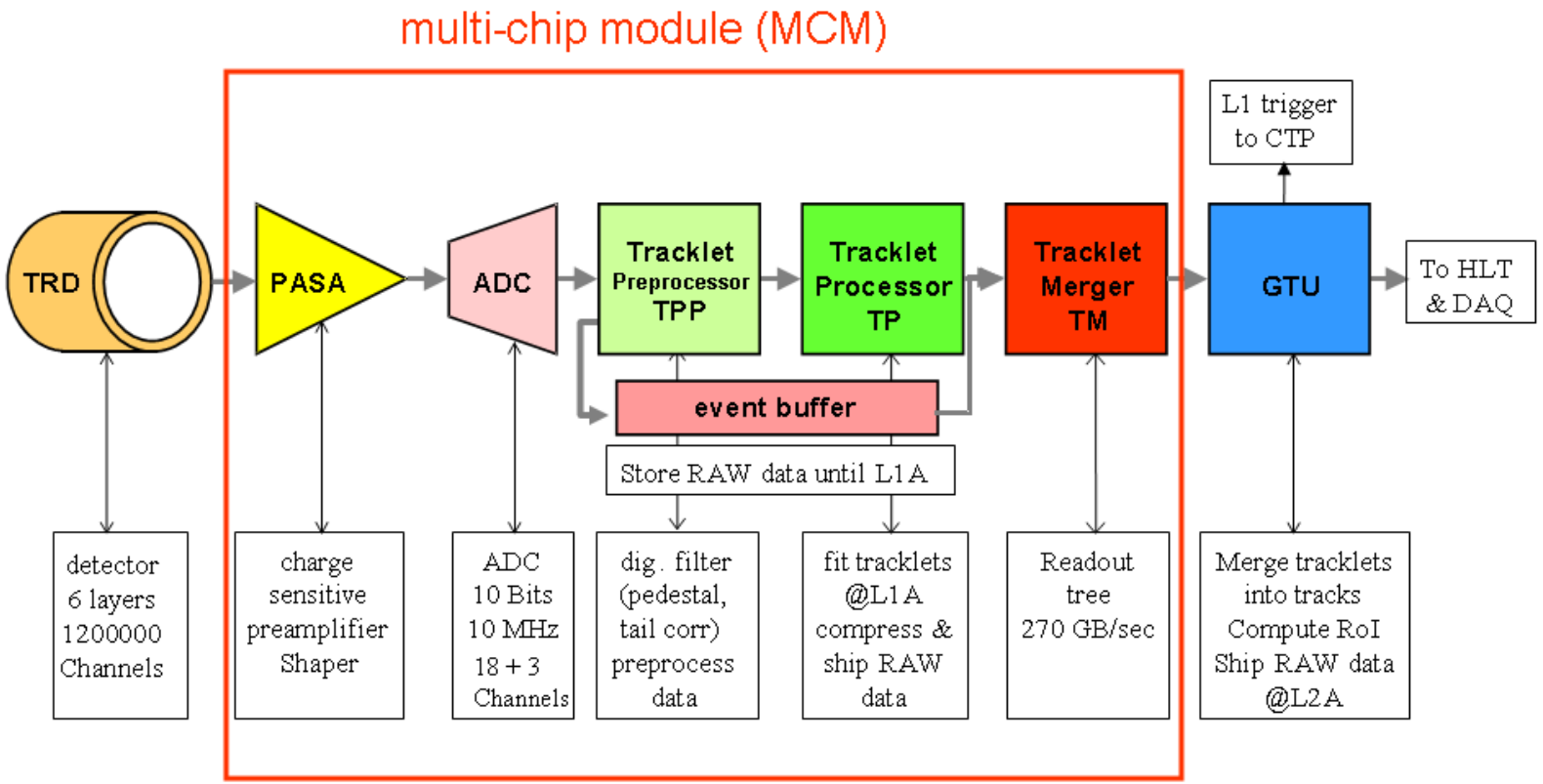
Heidelberg Chamber production

JINR Chamber Production Laboratory



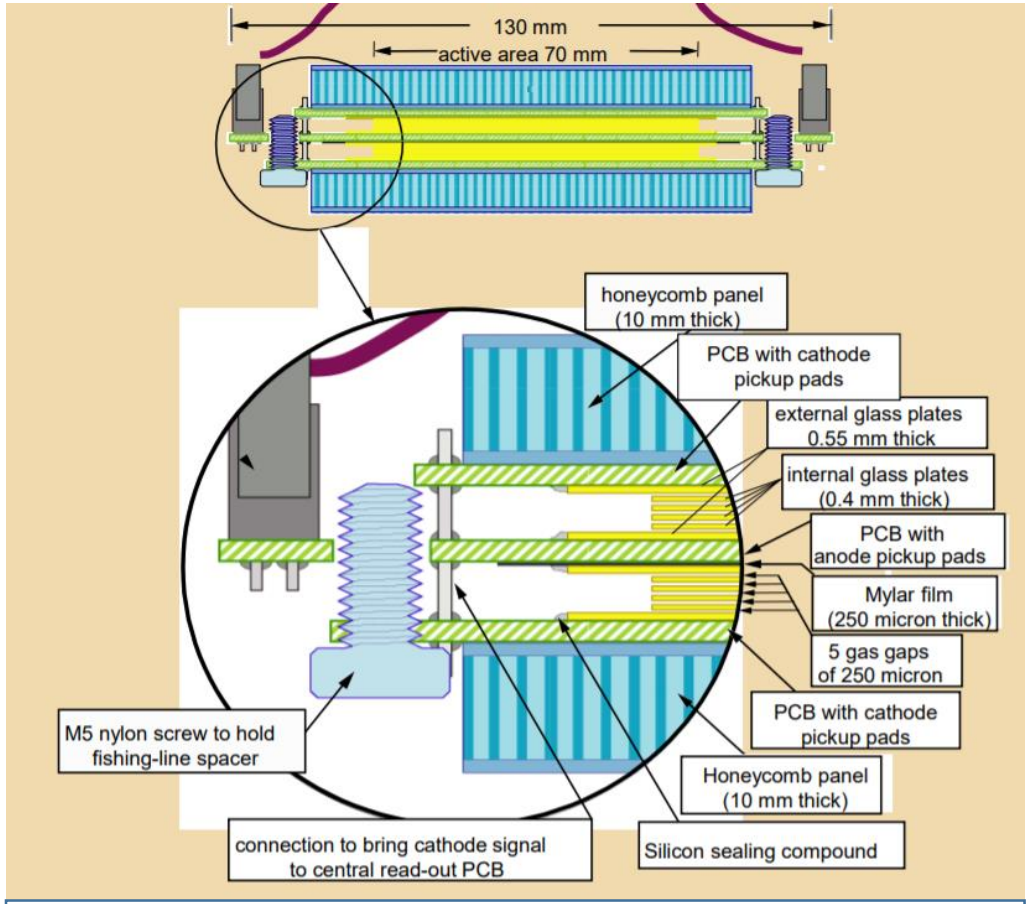
1 of 18 supermodules during assembly

TRD Signal processing: pushing state-of-the art



2 ASICs of 18 channels per MCM : PASA - AMS 0.35 µm
TRAP – 0.18 µm UMC containing ADC & digital processing
4 cpu's in 1 MCM for tracklet processing
16 + 1 MCM per read-out board

TOF: two time-honoured techniques revolutionized



The trick: use 10 detection gaps of 250 µm each

One of 18 Supermodules
8m long; 8000 TOF channels
Read out with NINO (the chip)

From RPC to M(ulti)RPC: motivated deeper understanding of the RPC detector physics

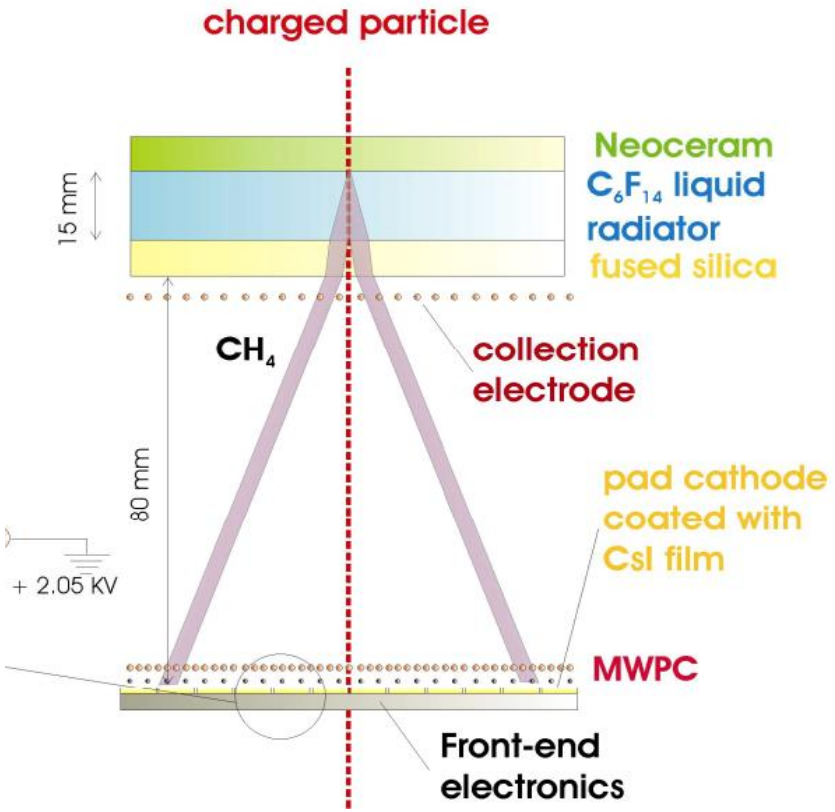
TOF: from sub-nsec timing to sub-100ps timing

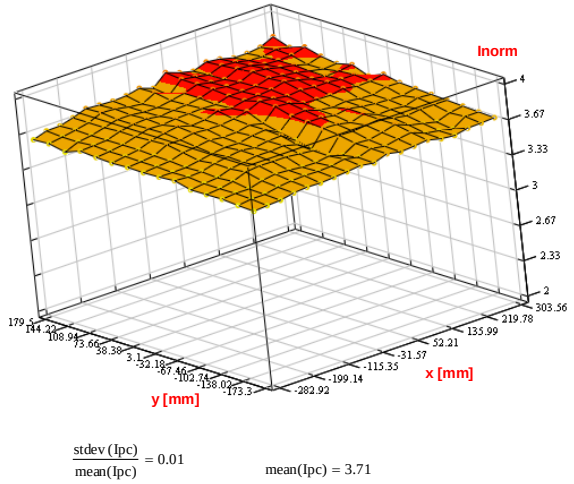
HMPID (High Momentum Particle Identification):
Every photon counts

CsI photocathodes; single-electron sensitivity: > 90 %
Proximity focusing

World's largest CsI photocathode system: 11 m^2
Photocathode efficiency: ~ 20%
uniformity: >5 %

Custom-built CsI evaporation plant for R&D, final cathode production



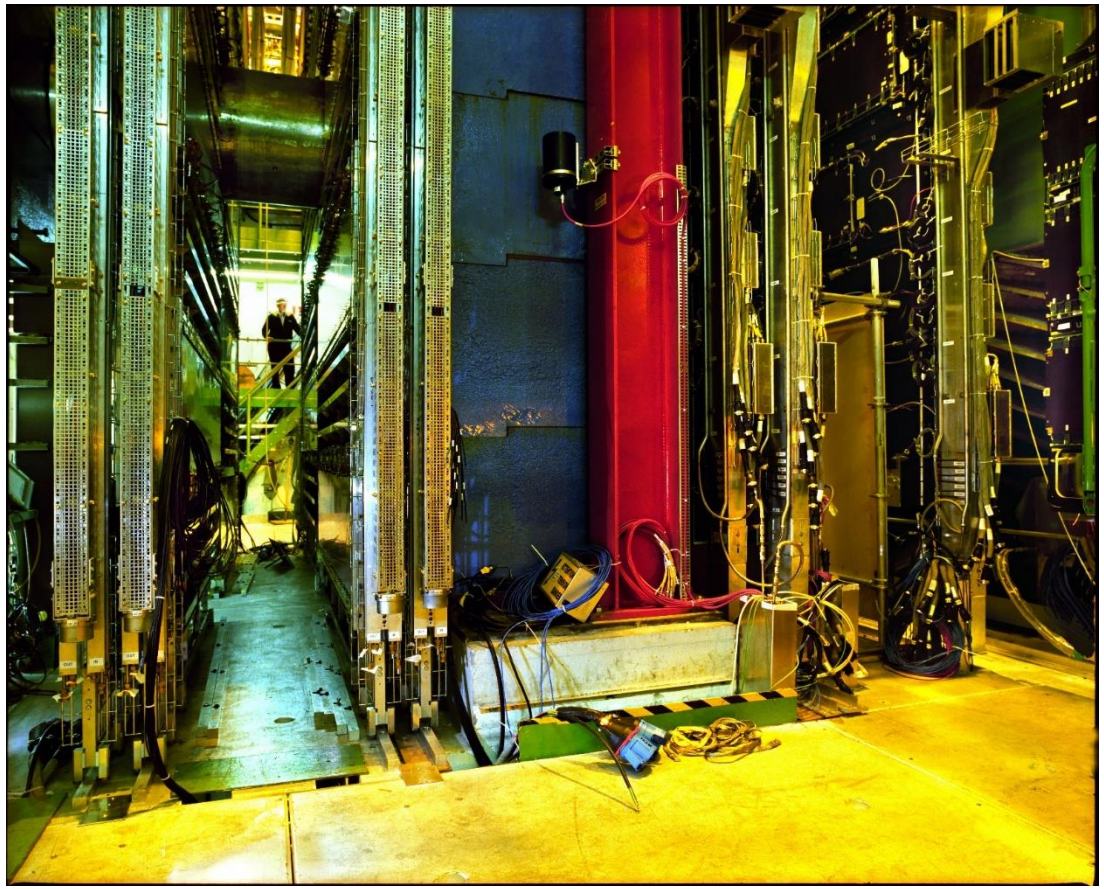


$\frac{\text{stdev (Ipc)}}{\text{mean(Ipc)}} = 0.01$ mean(Ipc) = 3.71

HMPID: assembled, ready for installation

Muon Tracking and Triggering: 1.3 * 10^6 readout channels 50 µm sagitta resolution; France, India, Italy, Russia

Successful chamber construction technology transfer
Readout chip “MANAS” designed, fabricated in India



Partial view of Muon Spectrometer with tracking and triggering chambers

PHOS: photon and electron crystal calorimeter

A Russia-led collaboration with Norway and Japan and CERN involvement

Choice of $PbWO_4$ crystals to match LHC performance goal

- Energy resolution ~ 3% / √ E
- Dynamic range from ~ 100 MeV to ~ 100 GeV
- Timing resolution of ~ 1.5 ns / √ E
- Trigger capability at first level

Readout electronics

- Reuse of major parts of TPC electronics

First module: May 2006

First batch from Apati factory (near Murmansk) with mastermind Slav Manko onlooking. It helped that Slav knew the minister of Atomic Energy …

First module: a very useful prototype

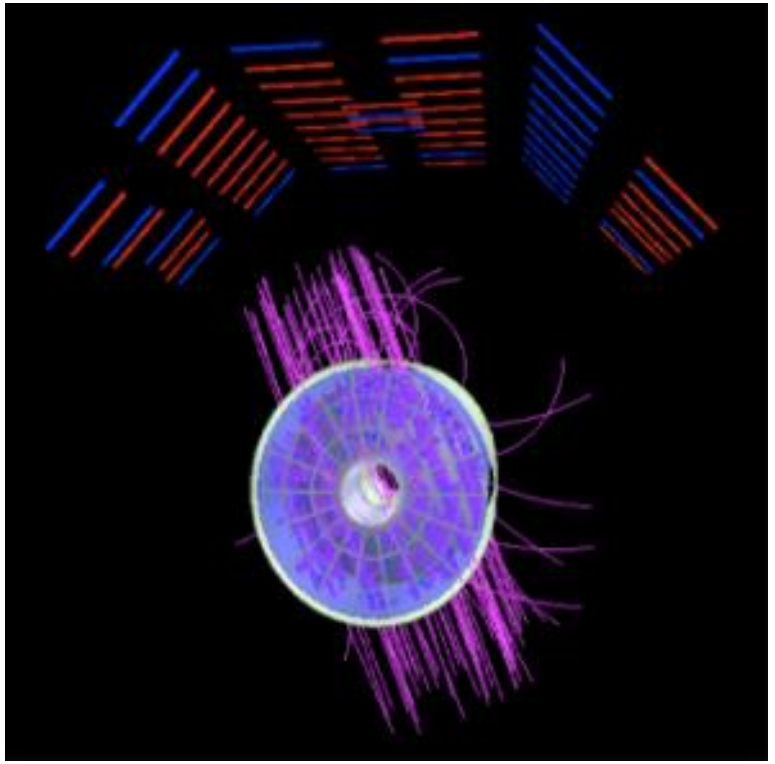
Entrance face

Back side Readout electronics

Crystals need to be cooled to -20 degrees; required redesign of enclosure to exclude air leaks and thermal bridges

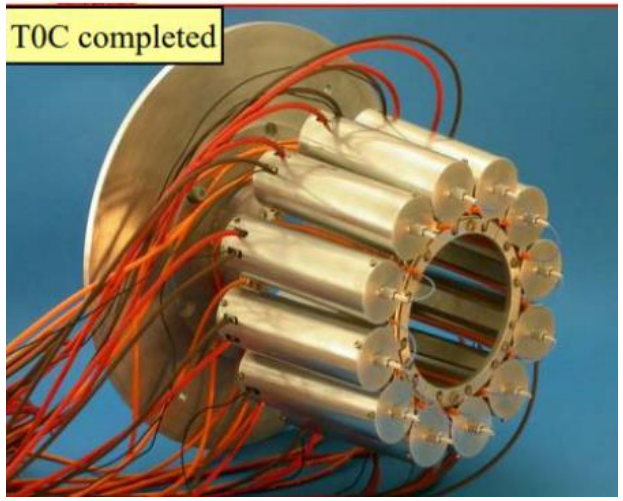
ACORDE: a new cultural and scientific contribution

Happy collaborators: Was the easy part of the installation….

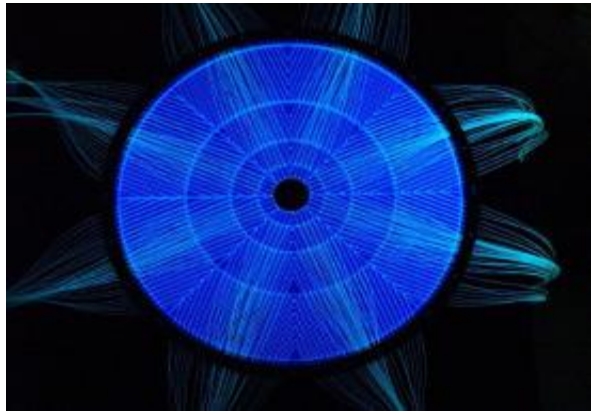


Cosmic Ray Event triggered by ACORDE Oct. 9th, 2008

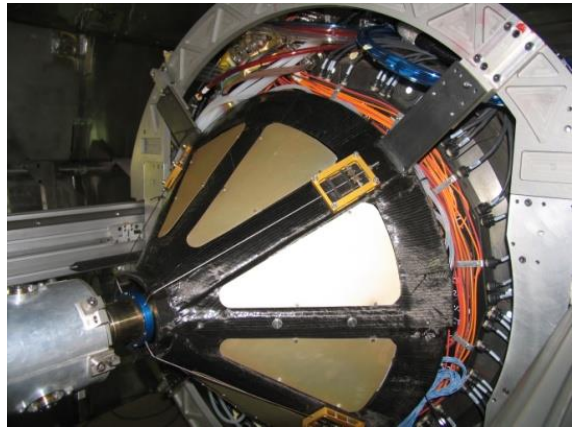
“Forward Detectors”: small, but important and with not so small challenges



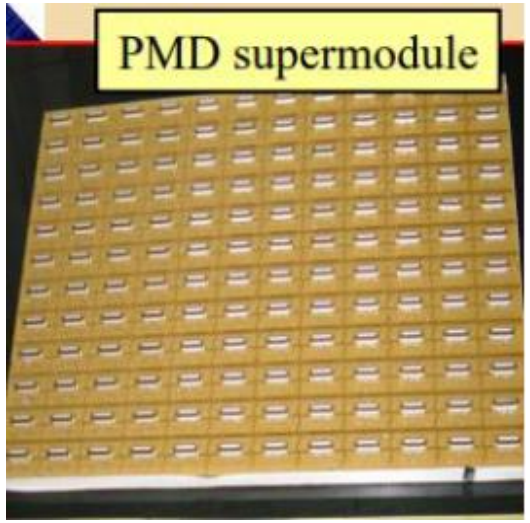
From Finland and Russia: 30 ps timing resolution: World record for scintillator based detector



V0 Multiplicity Detector: Scintillator tiles with fibre readout



Denmark in charge of the Si pad detector FMD



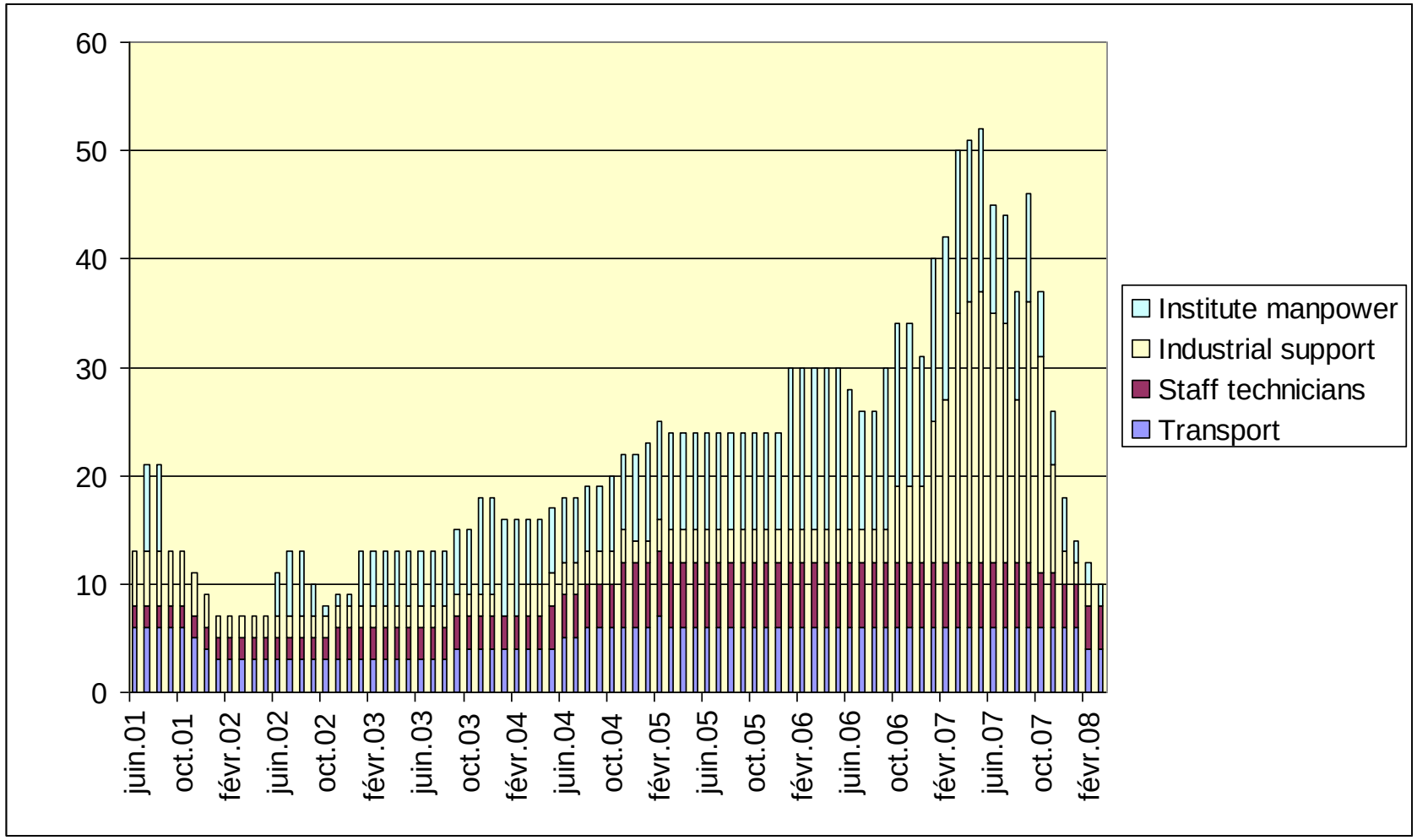
India led the Forward Photon Multiplicity Detector project

Proton ZDC at +- 116 m

Installation and integration

- Started with service installation already in 2002
- Extensive and very salutary pre-installation
- Installation climax in 2007 with a few close calls

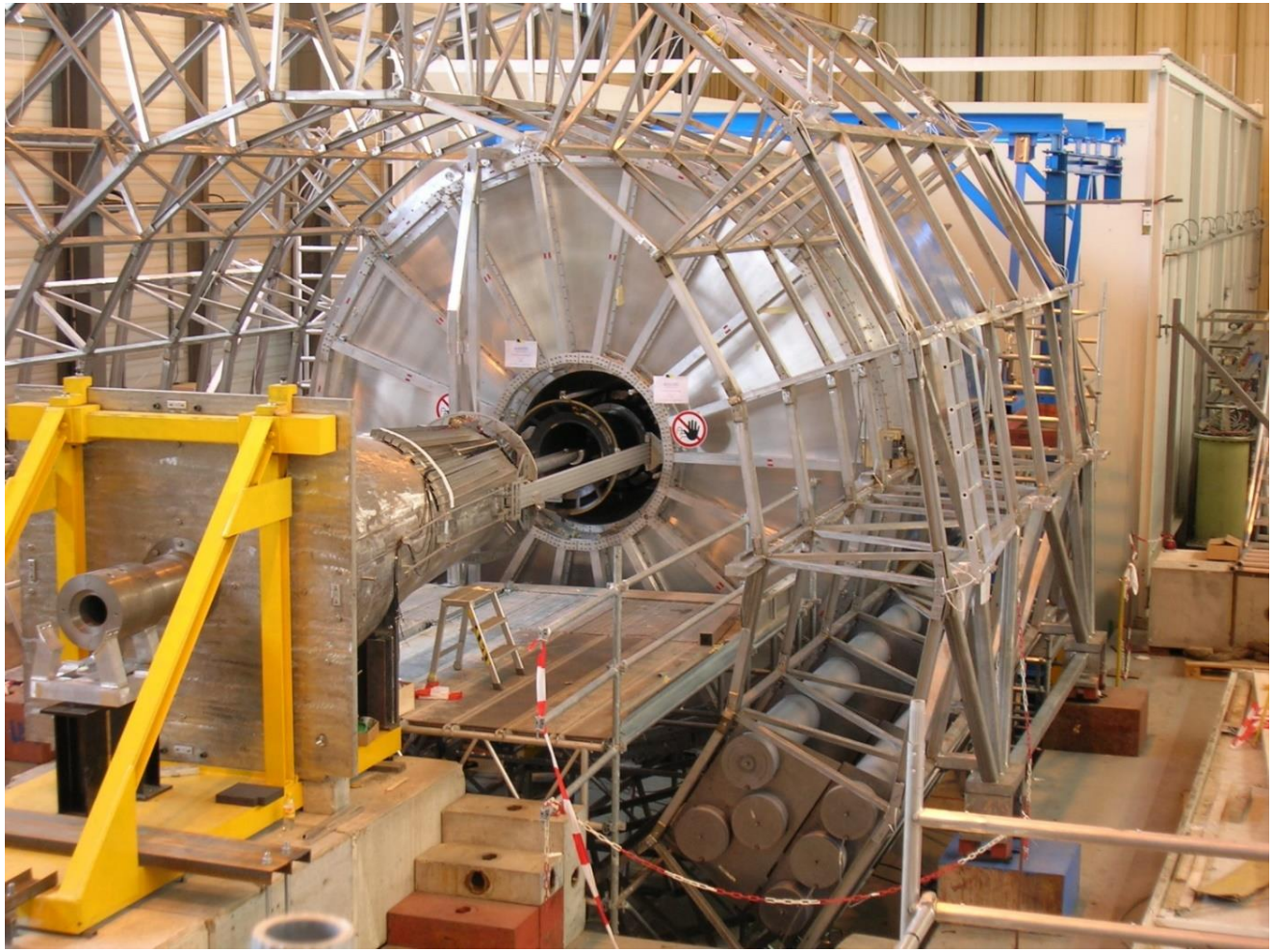
Evolution of personnel at Point 2



Integration test
Move of TPC into spaceframe

Integration test:

Delicately orchestrated movements of TPC/ITS/TRD/TOF/ Vacuum chamber/Front absorber

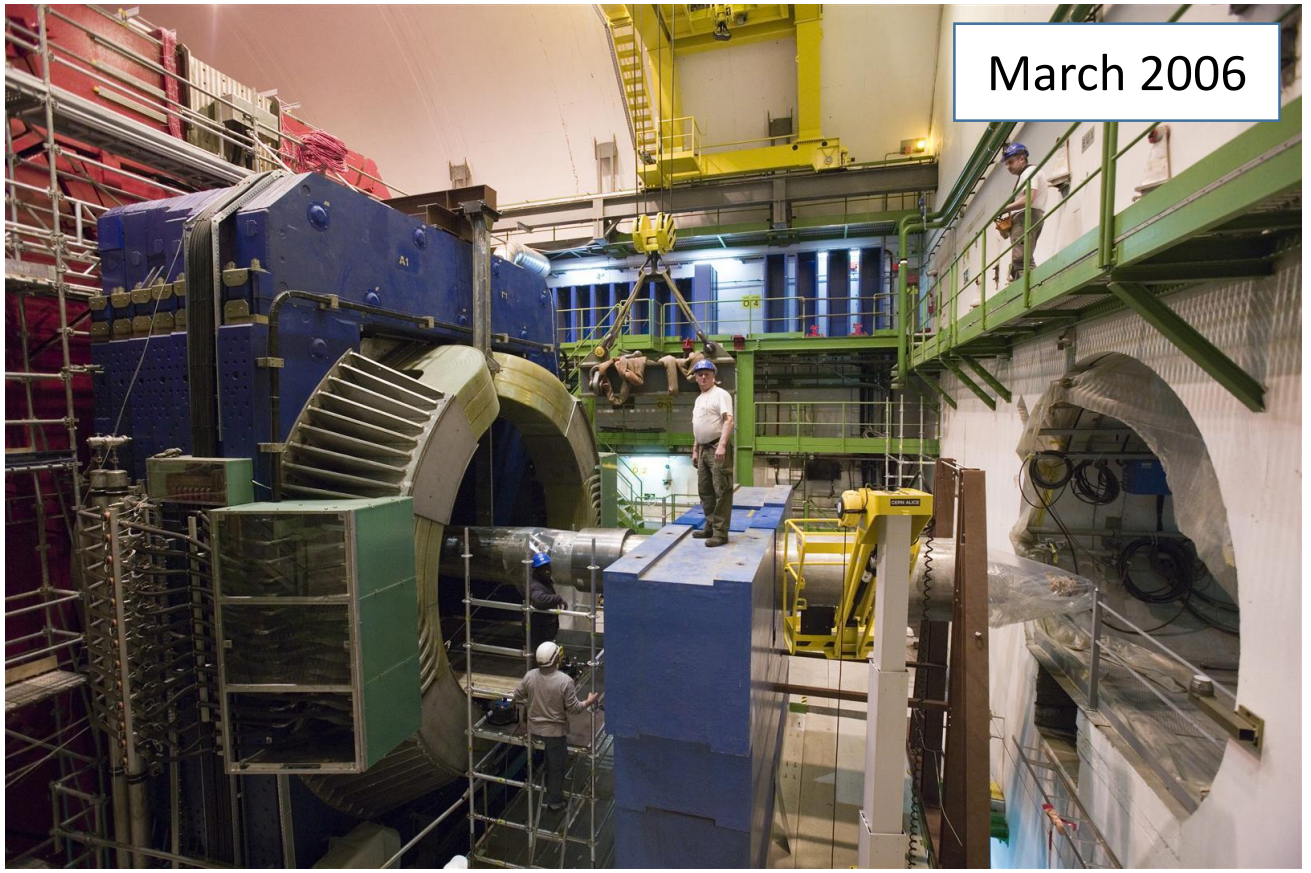


Aim: understand very complex installation sequence, deformations, lifting of detectors and…

TRD envelope crisis

Insertion test of dummy TRD Supermodule:
Result
Combined tolerances of SF and TRD insufficient
TC Pilgrimage to Heidelberg to discuss options
a) modify spaceframe
b) modify TRD
TRD collaboration accepted to modify TRD by shifting all modules radially
New module 1
Module 5 became modules 6
Consequences: TRD fits
Construction delay and 200 kCHF extra cost
Tense but constructive meeting in collaborative spirit

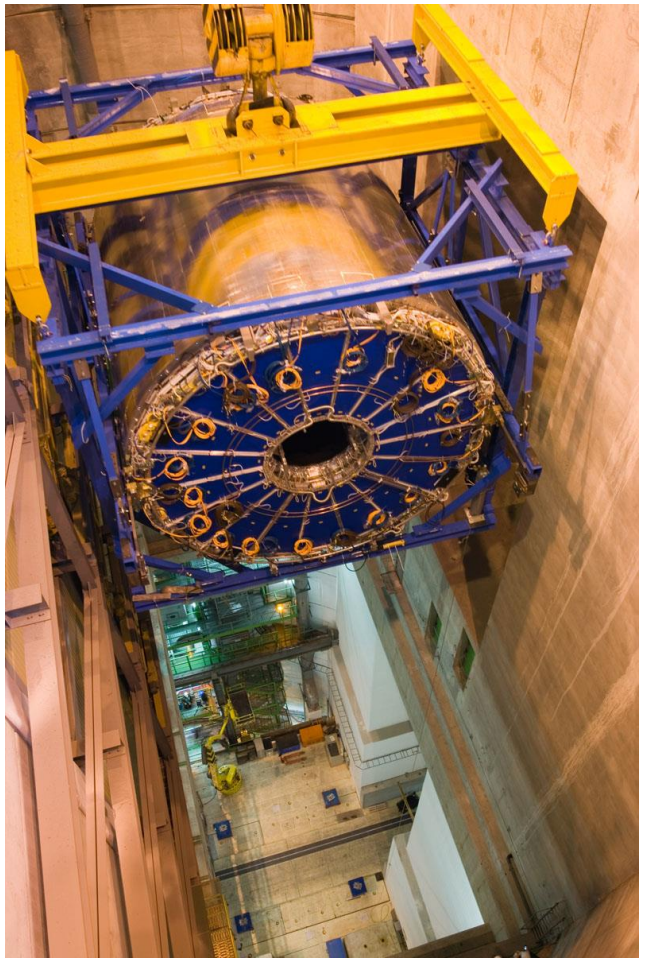
Getting serious: start of detector installation



Work on the front absorber.
The crane master of ceremony, Robert Porret, in command….

Jan. 8th, 2007, early morning: TPC moving into final habitat
It just stopped raining and snowing…

TPC levelled during transport to < 2 mrad



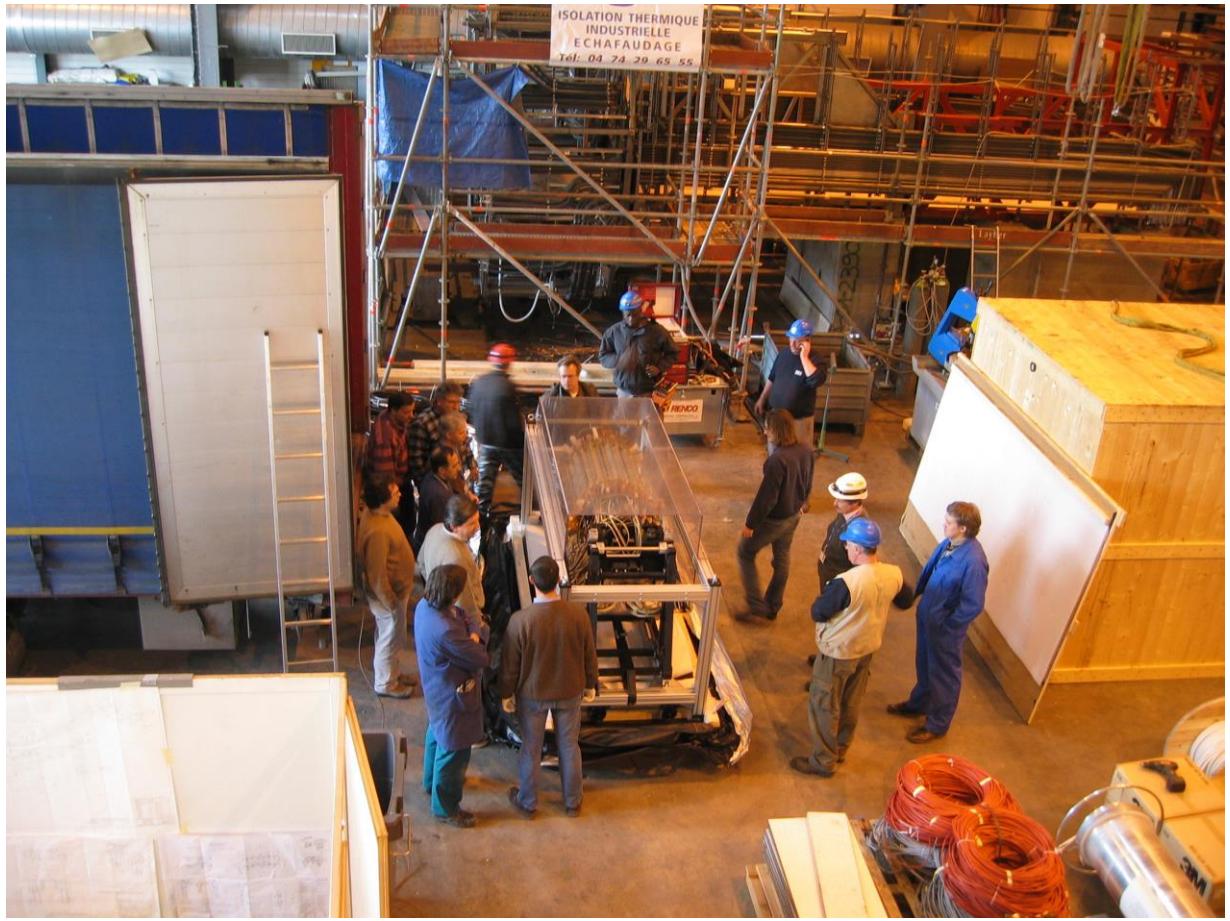
Lowering… it did fit…barely

Ready to install the first TRD supermodule

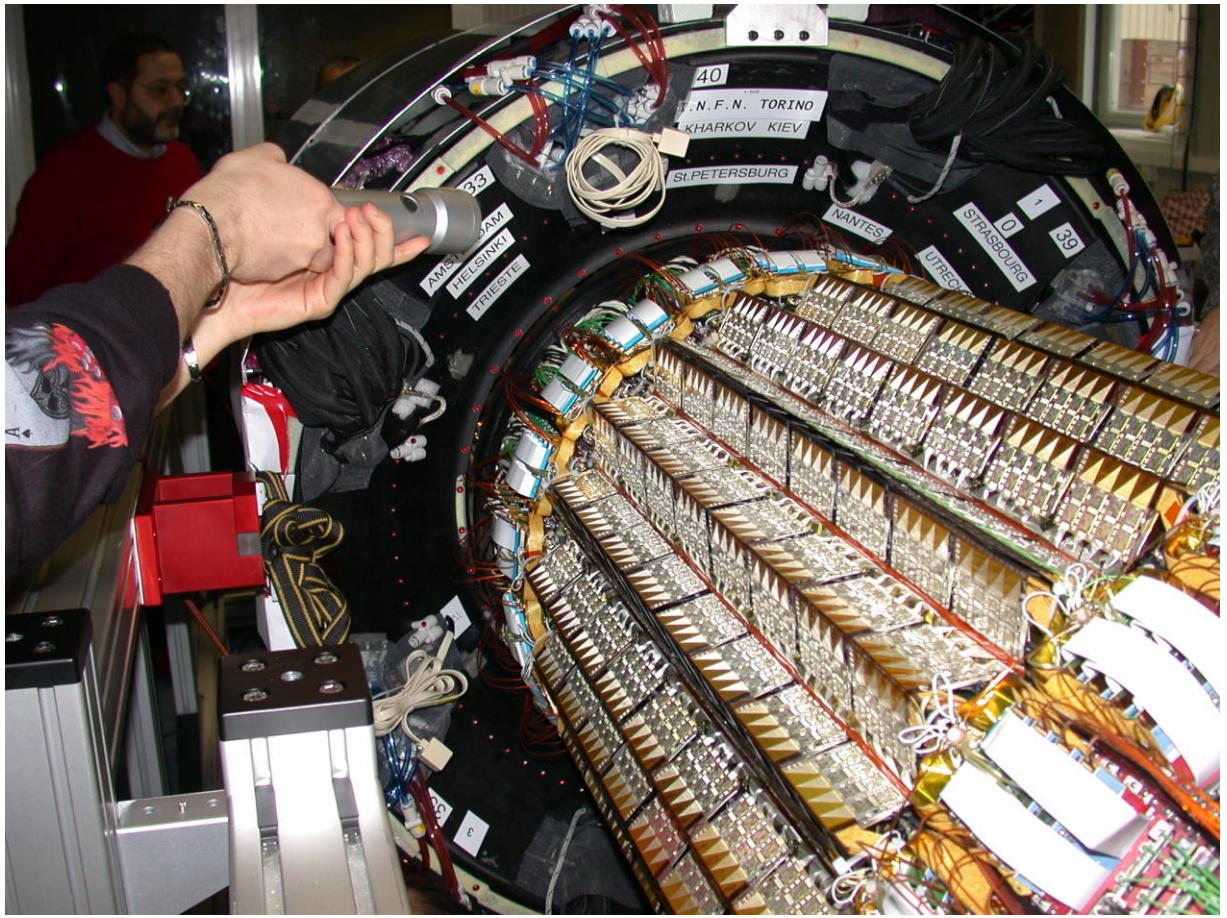
Installation tool (“Rotator”) recuperated from ALEPH

Demonstrating the value of the pre-installation: it fits
Supermodule being pulled into position

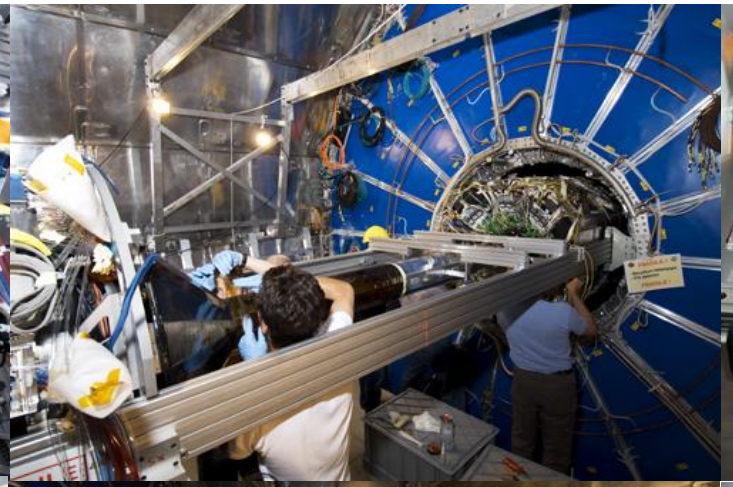
The ITS installation sequence required an unheard of level of dedication: celebrating Ferragosto 2007 working



SDD being unloaded

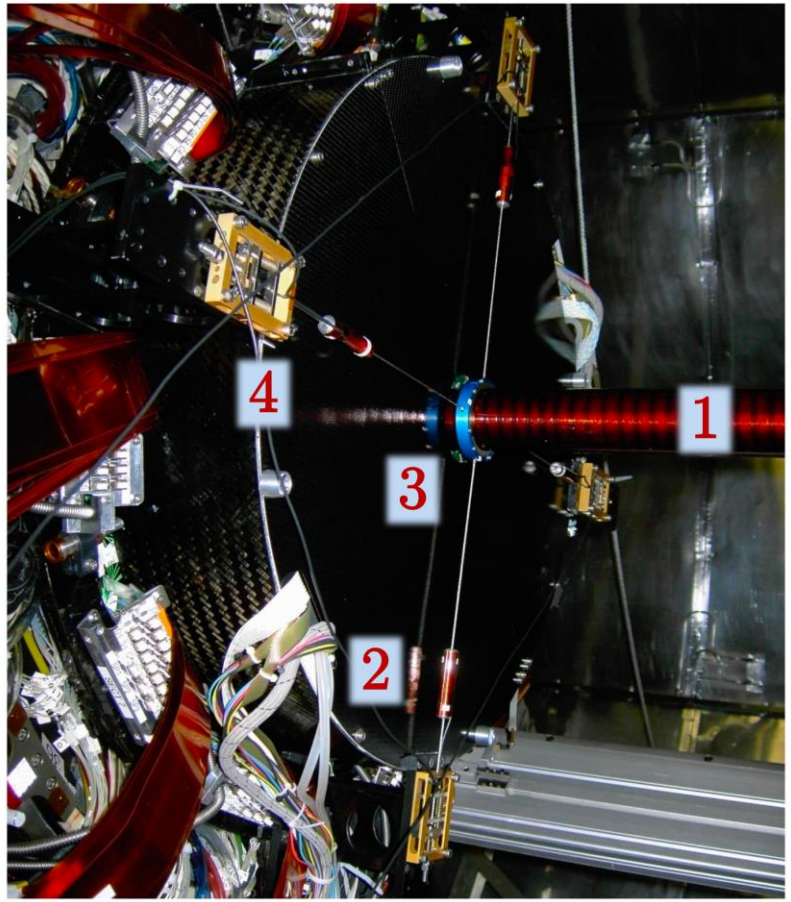


SDD insertion into SSD



ALICE SPD

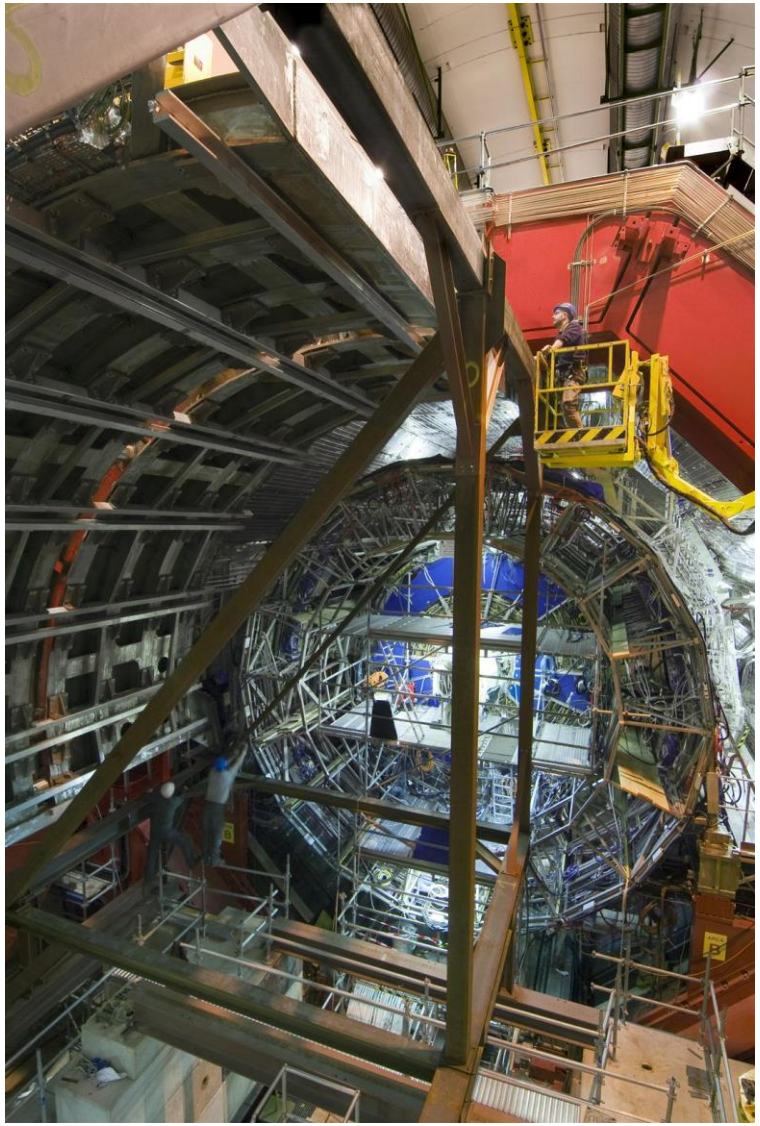
Close call: movement of detectors around beam pipe



ALICE beam pipe is supported in 3 points

During installation: many movements, displacing these points independently
Strain gauges were installed to monitor forces on vacuum pipe and deformations
During displacements test in preparation of TPC installation:
Force on one gauge much higher than calculated
Explanation: the spring in one of the support points got blocked during bake-out
Without this system of gauges….???

EMCal support frame, installed Nov. 2007



In early 2001: decision to leave room in Alice for a possible later installation of a calorimeter
(CF never before participated in an experiment without a decent calorimeter…)
Responsibility of our American collaborators, who successfully applied for construction funds
However, for logistics reasons support frame had to be built before project approval…

No risk, no fun

July 23rd, 2008

Finally…

(CF Report to CB on April 4th, 2008)

- It was a privilege and a pleasure to participate to Alice as Technical Coordinator and to work on our common goal to get Alice realized
- I would like to acknowledge the most constructive and collaborative attitude I met in the collaboration
- I enjoyed working again with colleagues from previous experiments and meeting many new colleagues
- Lars Leistam will provide the desirable continuity, while Werner Riegler will bring some needed fresh ideas and a youthful style

ALICE

Many happy returns!